Electronic Services - Los Angeles
M123363X

struction Manual

MODEL

1950A

DIGITAL COUNTER

FLUKE

JOHN FLUKE mfg. co., inc.

SEATTLE, WASHINGTON

MP MASTER
MA35521

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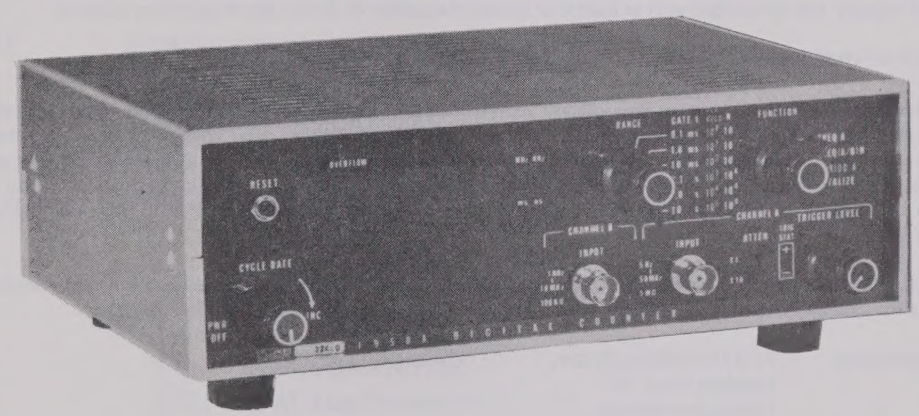

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APRIL 1974

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Rev. 3/74

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 1950A Multi-Function Counter is a high speed general purpose counter offering exceptional performance in a small, field-portable package. The 100% solid state design minimizes service problems and produces a rugged unit which can be taken and operated anywhere.

1-3. The 1950A has been designed to operate from either standard line voltage or an external 12 volt dc source, making this a truly versatile instrument for laboratory or field service work. The six digit display is constructed with large, bright, solid state digits offering high readability, even under high ambient light conditions. This display can easily be read from distances of 10 feet. Solid state light emitting diodes ("LED's") are used to indicate the measurement units, and in conjunction with the automatically placed decimal point, allow all measurement information to be seen at a glance. An LED overflow indicator warns when the input count has exceeded the display capacity. The measurement units are displayed directly behind the least significant digit. The overflow indication is located directly above the most significant digit. Both frequency and period units are illuminated.

1-4. The front panel "trigger level" control moves the threshold level up and down the incoming wave from, and is extremely easy to use in conjunction with two LED triggering status lamps. By balancing the light emitted from the two indicators, the proper triggering point can be located.

1-5. Display updating (cycle rate) is variable by means of a front panel control from 0.2 to 2.0 seconds. The reset button will reset the display to 000000 and initiate a new measurement. A rear panel slide switch and connector allows the 1950A to operate from an external 10 MHz timebase if required. The input sensitivity of channel A can be attenuated by a factor of 10, using a front panel slide switch.

1-6. The 1950A offers four operational modes. A front panel function switch is used to select one of the following: FREQ A, FREQ (A/B)N, PERIOD A, or TOTALIZE. When in the FREQ A or PERIOD A mode, the range of the display can be determined by a range switch. In FREQ A mode the range switch selects one of six decade stepped gate times from 0.1 ms to 10s. The range switch selects the number of input periods (10^0 to 10^5) to be averaged, when the PERIOD A mode is selected. In the FREQ (A/B)N mode the range switch determines the value of "N".

1-7. SPECIFICATIONS

FREQUENCY MEASUREMENTS

Range	5 Hz to 50 MHz
Gate Time	0.1 ms to 10 s in 6 decade steps
Accuracy	±1 count + timebase accuracy
Readout	kHz or MHz automatically displayed with decimal point

RATIO MEASUREMENTS

Displays	f1/f2 where f1 and f2 are applied separately at the two input jacks, A and B.
Range	
f_1	5 Hz to 50 MHz
f_2	1 KHz to 10 MHz
Accuracy	±1 count of signal on input A, + trigger error of signal on input B. (Input B trigger error is ±0.4% ÷ periods averaged for signals with better than 40 dB S/N ratio, and greater than 500 mV rms amplitude.)

PERIOD MEASUREMENTS

Range	5 Hz to 10 MHz
Periods Averaged	1 period to 10^5 periods in decade steps
Frequency Counted	100 kHz
Accuracy	±1 count + timebase stability + trigger error of signal on input A. (Input A trigger error is ±0.3% ÷ periods averaged for signals with better than 40 dB S/N ratio and greater than 100 mV rms amplitude. Error decreases as S/N and amplitude increase.)
Readout	ms or μs automatically displayed with decimal point.

TOTALIZING

Range	5 Hz to 50 MHz
Capacity	Counts up to 999999, then activates overflow indicator

SIGNAL INPUTS

Sensitivity	
Input A	Sinewave: 50 mV rms over entire frequency range of 5 Hz to 50 MHz. Pulse: 175 mV p-p pulse amplitude at minimum pulse width of 15 ns
Input B	600 mV rms sinewave 1 kHz to 10 MHz
Impedance	
Input A	1M in parallel with 30 pF
Input B	100k in parallel with 35 pF

Attenuator	Input A sensitivity is reduced 10 times when attenuator is in X10 position.
Overload Protection	**Input A** can withstand signals of up to 150V rms for frequencies up to 1 kHz. This value decreases to 5V rms (attenuator X1) or 50V rms (attenuator X10) at 50 MHz. **Input B** can withstand signals of up to 150V rms for frequencies up to 1 kHz decreasing to 5V rms at 10 MHz, dc + peak ac must not exceed 250V.

TIMEBASES

	STANDARD	OPTION –03	OPTION –04
Aging Rate	6×10^{-7}/day	5×10^{-8}/day	5×10^{-8}/day
(constant temp.)	2×10^{-6}/mo.	3×10^{-7}/mo.	3×10^{-7}/mo.
Short Term Stability	1×10^{-7}/m	5×10^{-8}	2×10^{-8}
(rms over 1 s)			
Temp. Dependence			
20°C to 30°C	1×10^{-6}	5×10^{-7}	1×10^{-7}
0°C to 50°C	5×10^{-6}	2×10^{-6}	3×10^{-7}
–20°C to 60°C	–	–	5×10^{-7}
Line Voltage Dependence (±10% Change)	1×10^{-7}	5×10^{-8}	2×10^{-8}

External Timebase Input

Frequency Required	10 MHz
Sensitivity	500 mV rms
Impedance	100 kΩ

OUTPUTS

Gate	Level goes to "1" state during actual sampling interval. "1" and "0" states are TTL compatible.
Clock	10 MHz square wave output derived from the counter's timebase. Output impedance 500 ohms; output level 4.5 volts peak-to-peak. BNC style connector.

OPTIONAL OUTPUTS

BCD	4 line 8-4-2-1 BCD output from each digit, TTL level high is true. High TTL print pulse, with a pulse width of 50 ms to 500 ms dependent on cycle rate control. Fanout is 3 54/74 loads.

1-8. GENERAL INFORMATION

Display	6 digit in-line display incorporating 0.27" high solid state, seven segment characters.

Cycle Rate	The time interval between successive measurements can be varied by means of a cycle rate control between approximately 0.2 to 2.0 seconds.
Storage Temperature Range	–40°C to +75°C
Operating Temperature Range	0°C to +50°C
Power Requirements	115 or 230V rms (switchable), 50 to 60 Hz, ±10% (100V version available), 3-wire supply, 16 watts, or 11.5 to 14V dc at 1.5 amps.
Fuses	AC - 1A (115V), 0.5A (230V) DC - 2A

Demensions (see Figure 1-1)

Width	9.26" - 23,5 cm
Height	2.95" - 7,5 cm
Depth	8.60" - 21,8 cm
Weight	5 pounds - 2,27 kg

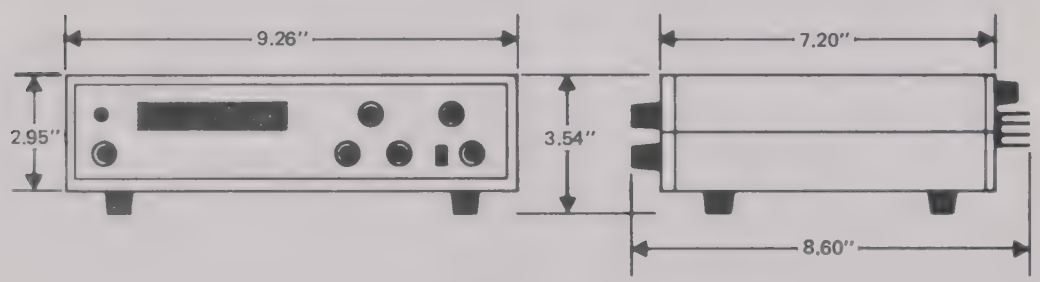


Figure 1-1. 1950A OUTLINE DRAWING

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section contains operating instructions for the Model 1950A Counter. It is recommended that the contents of this section be read before any attempt is made to operate this instrument. Operating instructions for options and accessories are provided in Section 6. Should any difficulties be encountered, please contact your nearest John Fluke Sales Representative, the John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133, Telephone (206) 774-2211 or John Fluke Mfg. Co. Ltd., 2247 Midland Ave., Scarboro, Ontario, Canada (416) 291-7777. A list of Sales Representatives is located at the rear of this manual.

2-3. SHIPPING INFORMATION

2-4. The Model 1950A was packaged and shipped in a foam packed cardboard carton. After unpacking the unit a thorough inspection should be performed to reveal any damage that may have occurred in transit.

2-5. If reshipment is necessary, the counter should be repackaged in the original container. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the model number (Model 1950A) when requesting a new shipping container.

2-6. INPUT POWER REQUIREMENTS

2-7. The counter may be operated from either 115 or 230V rms ± 10%, 50 to 60 Hz line power. A slide switch, located on the rear panel of the unit, selects either the 115 or 230 volt line power requirement.

2-8. OPERATING FEATURES

2-9. The location and function of all front panel controls, connectors, and indicators are shown and described in Figure 2-1 and Table 2-1. The location and function of all rear panel controls and connectors are shown in Figure 2-2 and described in Table 2-2.

2-10. OPERATING NOTES

2-11. The following paragraphs describe various conditions which should be considered prior to operating the Model 1950A.

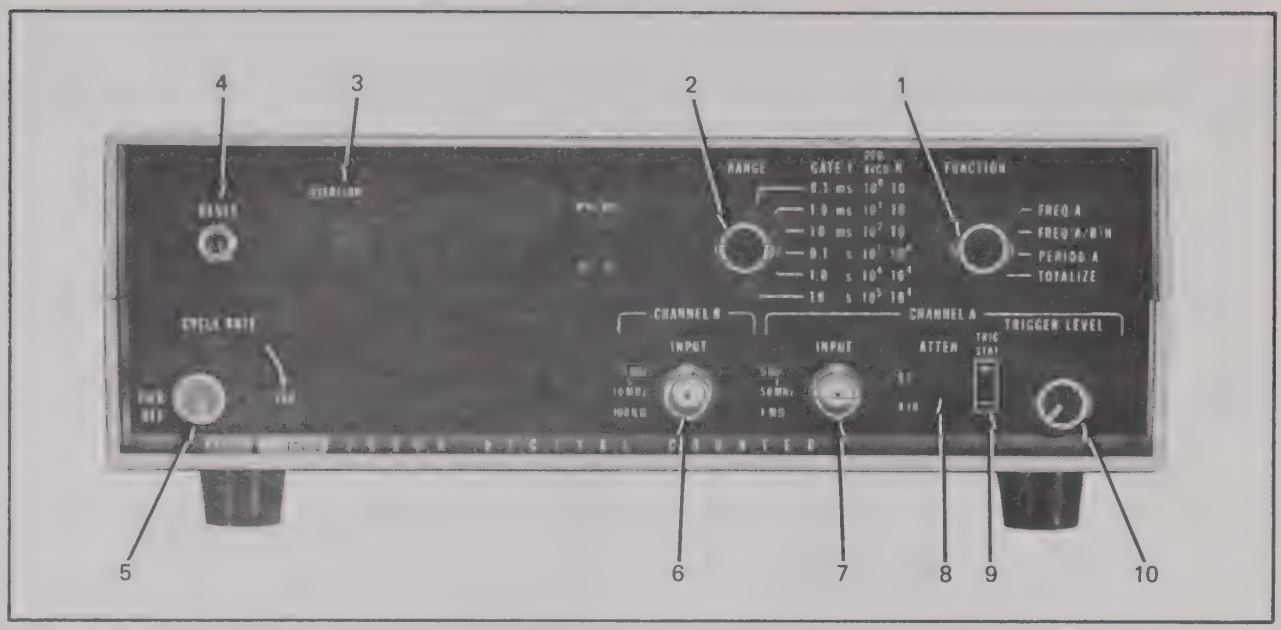


Figure 2-1. FRONT PANEL CONTROLS AND INDICATORS

Table 2-1. FRONT PANEL CONTROL AND INDICATOR FUNCTIONS

REF NO	NAME	FUNCTION
1	FUNCTION switch	Selects the counter function
2	RANGE switch	When measuring FREQuency A, the RANGE switch selects the gate time (white letters). When measuring PERIOD A the RANGE switch selects the number of periods to be averaged (yellow letters).
3	OVERFLOW Indicator	Illuminated when the input count exceeds the 1950A display capacity.
4	RESET button	Resets the display counters, clears the program logic, and in the FREQ A or PERIOD A mode initiates a new measurement.
5	CYCLE RATE Control	Selects a time interval between measurements of 0.2 seconds (fully cw) to 2 seconds. The fully ccw position turns the unit off.
6	Channel B Input	Used only when measuring frequency ratios in the FREQ (A/B)N.
7	Channel A Input	Connects inputs to preamplifier A in the FREQ A, PERIOD A, and TOTALIZE modes.
8	ATTENuator	Has no effect on input in X1 position. In the X10 position input A is reduced ten times before it reaches the preamplifier.
9	"+" and "—" indicators	Show the status of the input signal level in relationship to the trigger level threshold. The "+" indicator is energized when the instantanious input voltage is above the threshold and "—" indicator energizes when the input level is below the threshold.
10	TRIGGER LEVEL	Determines the minimum input signal level required to cause the buffer amplifier amplifier to conduct.

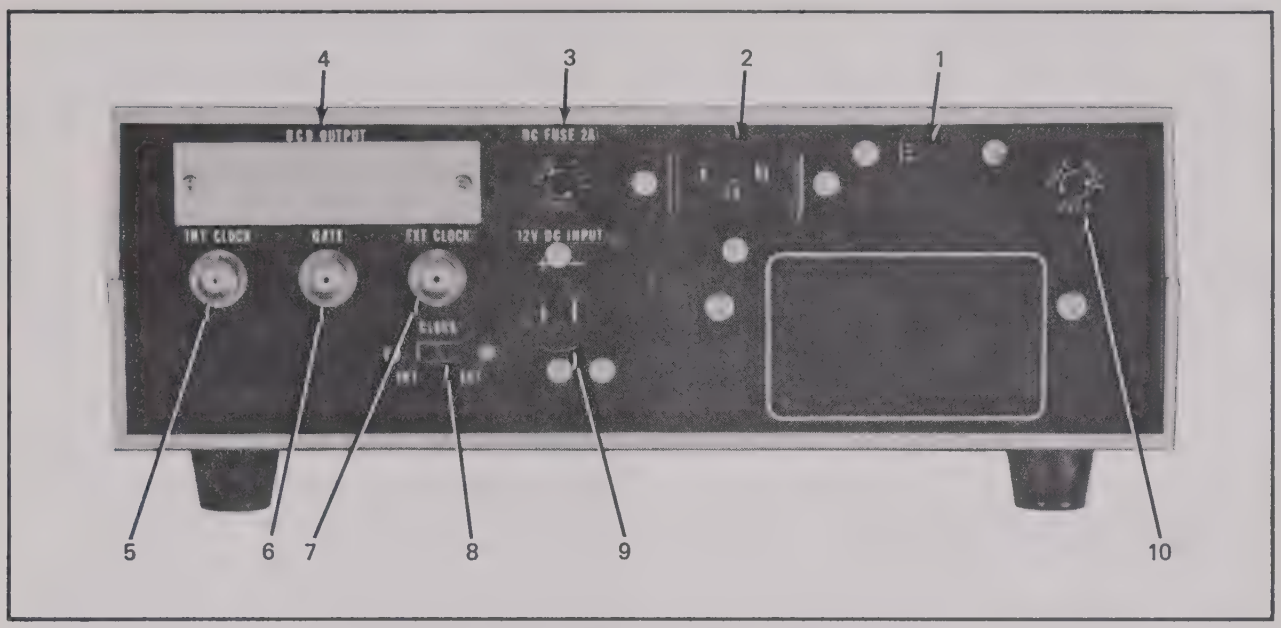


Figure 2-2. REAR PANEL CONTROLS AND CONNECTORS

Table 2-2. REAR PANEL CONTROLS AND CONNECTOR FUNCTIONS

REF NO	NAME	FUNCTION
1	Input power select switch	Selects 115V or 230V ac power input.
2	AC power input	Connects an ac line power source to the counter.
3	2A fuse	Provides protection for dc power input.
4	BCD output	Provides 8, 4, 2, 1 bcd outputs when the option is installed.
5	INTernal Clock jack	Provides the internal clock frequency as an output.
6	GATE jack	Allows the main gate "gate-time" to be used externally.
7	EXTernal Clock jack	Used to supply the counter with an external 10 MHz clock oscillator.
8	CLK INT-EXT selector switch	Selects either the internal or external clock oscillator source.
9	12V DC input	Allows the unit to be operated from a 12V dc source.
10	1A or 0.5A fuse	provides 1A fuse protection for 115V ac input power and 0.5A for 230V power

2-12. AC Line Connection

2-13. The input power cord is a three-prong polarized connector and cable which permits connection to a grounded outlet. Ensure that the ground pin is connected to a high quality earth ground. Locate the 115/230-volt selection switch on the rear panel and slide it to the position required for local line voltage, i.e. 115V ac or 230V ac. When the counter is connected to ac line power, the front panel CYCLE RATE control is turned cw to energize the unit.

2-14. Overload Protection

2-15. The rear-panel mounted line power fuse should be selected in accordance with the local line power voltage. The recommended fuse type is 3AG, with a one-ampere rating for 115V ac applications, and 0.5 amperes for 230V ac applications.

CAUTION!

Do not defeat the purpose of the line power fuse by inserting one of higher current rating than specified for the local line voltage.

2-16. Input Connections

2-17. All signals to be measured are applied to the 1950A via the front-panel input connectors. The connectors are BNC-type. A shielded cable assembly equipped with a mating BNC connector should be used for application of the signals to be measured.

2-18. FUNCTIONAL OPERATION

2-19. The 1950A control settings for each function are outlined in the following paragraphs. The applications for the described functions have been added in order to associate the control settings with a particular counter use.

NOTE!

The Clock INT EXT switch MUST be in the INT position unless an external 10 MHz clock is being used.

2-20. Frequency Measurements

2-21. The 1950A is capable of digitally displaying the frequency of inputs signals within the range of 5 Hz to 50 MHz. This function of the counter is used for accurately determining the frequency of an unknown signal source. The counter controls can be set for frequency measurements as follows:

a. Turn the counter on by rotating the CYCLE RATE control cw out of the PWR OFF position.

b. Set the FUNCTION switch to FREQ A

c. Connect the unknown input signal to CHANNEL A INPUT connector.

d. Adjust the TRIGGER LEVEL for equal illumination of the + and – TRIG STAT indicators.

NOTE!

Equal illumination of the + and – TRIG STAT indicators is for symetrical wave forms inputs only.

e. Set the RANGE switch to a gate time that will display the greatest number of digit of the frequency without lighting the OVERFLOW indicator.

f. Adjust the CYCLE RATE as desired

2-22. Frequency Ratio Measurements

2-23. In the FREQ (A/B)N function, the ratio of two signals is determined by gating the counter with the lower frequency signal (CHANNEL B INPUT) while counting the number of cycles of the higher frequency signal (CHANNEL A INPUT) occurring in that time. Ratio measurements are made by setting the controls as follows:

a. Turn the counter on

b. Select the FREQ (A/B)N function

c. Connect the higher of the two signal inputs to CHANNEL A INPUT and the lower to CHANNEL B INPUT (input B must be a minimum of 600 mV rms).

d. Set the TRIGGER LEVEL control for even illumination of the TRIG STAT indicators.

e. The RANGE switch selects the value of the "N" multiplier as a correction factor for the decimal.

2-24. Period Average Measurements

2-25. Period measurements of low frequency signals are preferred over frequency measurements due to the improved accuracy and resolution. The counter controls can be set for period measurements by positioning the controls as follows:

a. Turn the counter on

b. Set the FUNCTION control to PERIOD A

c. Connect the unknown signal input to CHANNEL A INPUT connector.

d. Adjust the TRIGGER LEVEL control for even TRIG STAT indicator illumination

e. Set the RANGE switch to the desired number of periods to be averaged.

2-26. Totalize Measurements

2-27. The totalize mode of operation is useful when counting the cycles of a very low frequency signal, the pulses of a non-repetitious pulse train or other similar events over a relatively long period of time. Totalize measurements may be made by positioning the controls as follows:

a. Turn the counter on

b. Set the FUNCTION control to TOTALIZE

c. Connect the input signal to the CHANNEL A INPUT connector

d. Adjust the TRIGGER LEVEL control for even TRIG STAT indicator illumination (for symetrical wave forms), or until the counter read out indicates steady counting of the input.

2-28. Battery Operation

2-29. The 1950A can be operated from an external 12 volt dc source. A minimum of 11.4V dc, including ripple, is required to operate the counter. The maximum allowable ripple is 0.5 volts peak-to-peak. The dc source can be connected to the counter before the ac is disconnected without interruption of normal counter operation.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. Generally, the frequency of a signal is measured by counting the number of complete cycles of the unknown signal that occur during a known time interval. A digital frequency counter is designed to "sample" the incoming wave form for a precisely controlled length of time and count the number of cycles that occur during this time. The actual count is applied to a "count and display" section where a number of high speed flip-flops connected in series, decimally count and display the input. A "program logic" section is required to control the repetitive requirements to reset the counters, open the sample gate, close the sample gate, update the display, and then reset the counters again. The timing of these events is usually controlled by the output of a stable crystal oscillator.

3-3. The theory of operation for the model 1950A multi-function counter is presented in the following paragraphs. Figure 3-1 shows a basic block diagram of the 1950A. The functional purpose of each section is discussed separately.

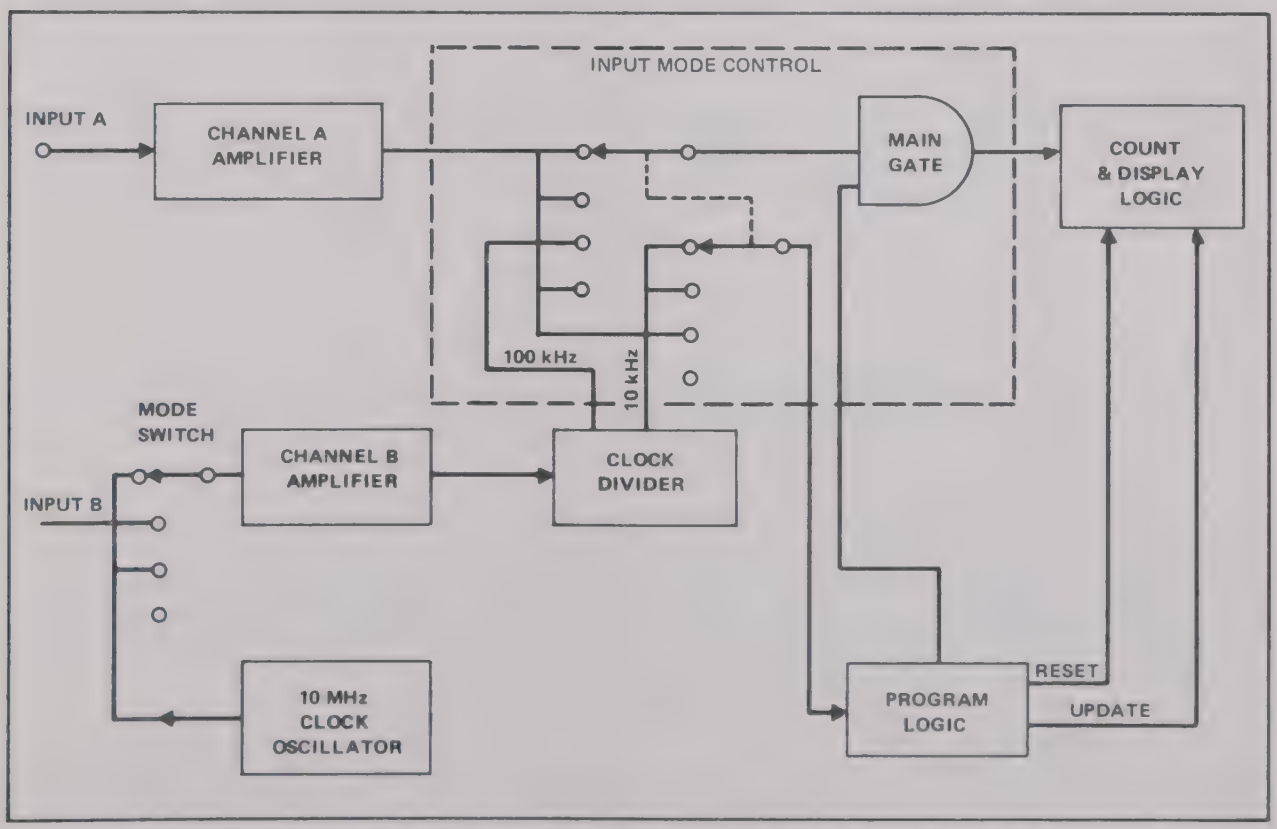


Figure 3-1. MODEL 1950A BLOCK DIAGRAM

3-4. CHANNEL A AMPLIFIER

3-5. The input signal is ac coupled to the X1/X10 attenuator slide switch, as shown in Figure 3-2. In the X10 attenuator position the level of the input signal is reduced 10 times. An input buffer provides for broadband frequency coverage with high input impedance. The buffered input signal is amplified, then shaped into square waves by the schmitt trigger. The last stage of the input amplifier translates the schmitt trigger output into TTL (Transistor-Transistor Logic) levels for use in the function control section.

3-6. CHANNEL B AMPLIFIER

3-7. Amplifier B takes a signal from either the 10 MHz timebase oscillator, in the frequency A and period average modes, or from input jack B in the frequency (A/B)N mode. When the function switch is in the totalize position the input to preamp B is disconnected.

3-8. The input signal, as selected by switch S3A, is capacitively coupled to an input buffer stage that offers 100k ohms of input impedance to the incoming signal. Figure 3-3 illustrates the signal conditioning of input B. From the buffer the sine wave input is applied to a schmitt trigger where it is converted to a square wave equal in frequency to the input signal. The square wave from the schmitt trigger is then translated to a TTL compatable square wave before going to the clock divider.

3-9. CLOCK DIVIDER

3-10. The output of amplifier B is connected to the input of the first of three, series connected, high-speed TTL decade counters. Each counter divides its input by ten. The clock divider has two outputs. The first, equal to the frequency output of amplifier B divided by 100, is taken from the output of the second counter. The second, taken from the output of the third counter, is equal to the amplifier B frequency divided by 1000. When the counter is in the frequency A, or period average mode, the output frequency of amplifier B is the 10 MHz clock signal. The first and second clock divider frequencies are 100 kHz and 10 kHz respectively. In the frequency (A/B)N mode the output frequency of amplifier B is variable, therefore the two divider outputs will be variable. There will not be an output from the clock divider in the totalize mode because the input to amplifier B is disconnected.

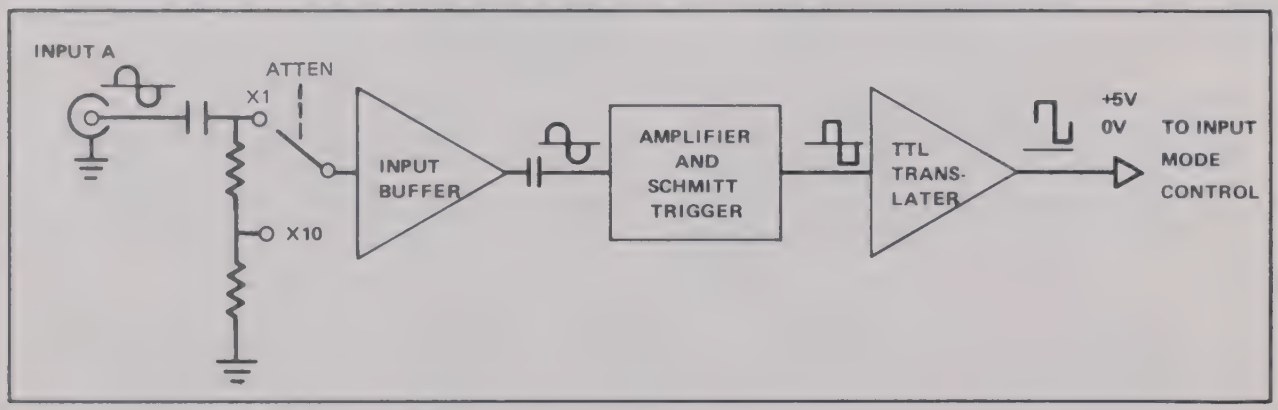


Figure 3-2. CHANNEL A AMPLIFIER

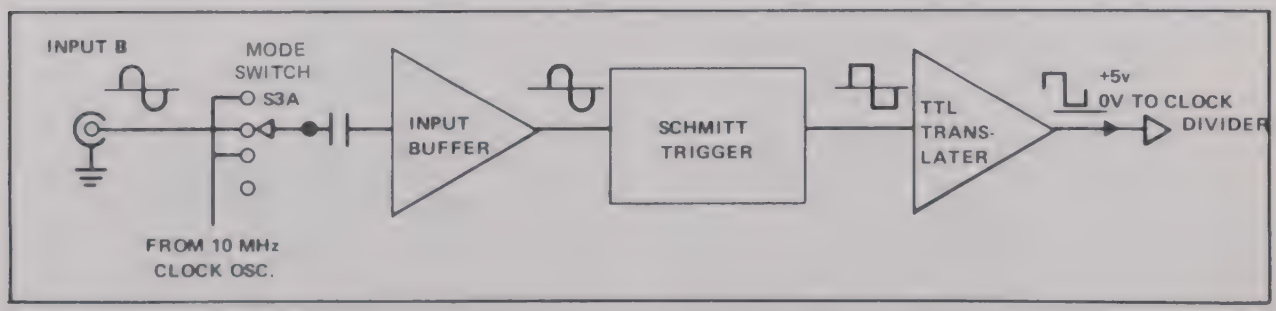


Figure 3-3. CHANNEL B AMPLIFIER

3-11. INPUT MODE CONTROL

3-12. In Figure 3-1 the input mode control is illustrated, for ease of understanding, as two manually positioned switches. Figure 3-4 shows the actual configuration of the circuit. The logic gates will be identified by item identification (U1) followed by output pin number (U1-8). Section S3B of the mode switch controls the nand gates that select the input signal for the count and display logic and the gate time signal for the program logic.

3-13. The input mode control for each function switch setting is presented separately.

a. In the frequency A mode the signal from the input A amplifier is gated through nand gates U1-8 and U2-12 to the main gate. The control signal for the main gate is derived from the 10 kHz clock divider signal, directed through nand gates U6-6 and U6-8 to the program logic. From the program logic the selected gate time is processed through nand gate U7-8 and applied to the main gate where it enables the main gate to pass the frequency from amplifier A to the count and display logic for the duration of the gate time signal.

b. In the frequency (A/B)N mode the signal to be counted by the count and display logic again comes from the input A amplifier to the main gate via nand gates U1-8 and U2-12. The frequency of the gating signal from the clock divider depends upon the frequency of the signal applied to input B. The 10 kHz clock divider output is gated through nand gates U6-6 and U6-8 to the program logic, then from the program logic to the main gate.

c. In the period average mode the 100 kHz signal from the clock divier, via nand gate U2-6, is gated through the main gate and counted by the count and display logic. The signal from the input A amplifier is gated through nand gates U1-8, U6-11 and U6-8 to the program logic. The control signal out of the program logic goes through nand gate U7-8 to the main gate and holds it open for a controlled length of time, during which the 100 kHz signal is counted.

d. In the totalize mode, the main gate is held open by the output of nand gate U7-8. The signals out of input amplifier A are directed through nand gates U1-8, U2-12, and the open main gate, to the count and display logic.

3-14. PROGRAM LOGIC

3-15. The program Logic receives the gate signal, as selected by the input mode control, that will produce the proper reset and update signals, and gate times that correspond to the counter's mode of operation. Figure 3-5 is a block diagram of the program logic showing a 10 kHz input gating signal. The 10 kHz signal input is for frequency A and period average modes, during frequency (A/B)N the input signal will be the input B frequency divided by 1000. In the totalize mode the program logic input is disconnected. The 10 kHz input signal will be used in the following discussion of the program logic circuit.

3-16. A count cycle starts with the five decade dividers reset and the Q output of the four J-K flip-flops at logic "0". The $\overline{Q}$ outputs of the J-K's are at +5V (logic "1"). At this point the logic 0 on the Q output of the first J-K will open the main gate of the input mode control and the count and display logic will start to count the input frequency.

3-17. At the end of 100 cycles of the 10 kHz signal the output of U16 (pin 11) will clock U13 pin 1, causing the flip-flop to change state. With the Q output (pin 15) now at a logic "1" the main gate closes, cutting off the input signal to the count and display logic. The logic "0" at the $\overline{Q}$ output disables nand gate U7-3 and causes U7-6 to change from logic "0" to logic "1". The logic "1" output of nand gate U7-6 will reset the decade dividers and, with the logic "1" from the $\overline{Q}$ output of U13-10, insures that U9-11 remains at a logic "0" to inhibit the update command.

3-18. The cycle rate multivibrator generates a TTL square wave at a frequency set by the cycle rate control. At this point, the next negative transition of the cycle rate square wave will clock U13-6. The $\overline{Q}$ output drops from a logic "1" to a logic "0" causing nand gate U9-11 to supply the display with and update command. The next negative transition of the cycle rate square wave will clock flip-flop U14-1 causing the Q output (pin 12) to produce a logic "1" and the $\overline{Q}$ output (pin 13) to drop to a logic "0". The negative transition of the 10 kHz clock divider signal will clock U14-6 causing the Q output (pin 9) to go to logic "1". The logic "1" will enable nand gate U9-8 to reset flip-flops U13 and, through nand gates U9-3 and U9-6, send the reset command to the count and display logic. As U13 is reset the $\overline{Q}$ output at pin 14 provides a logic "1" to enable nand gate U7-3 and the Q output drops to logic "0" to open the main gate and start a new count cycle.

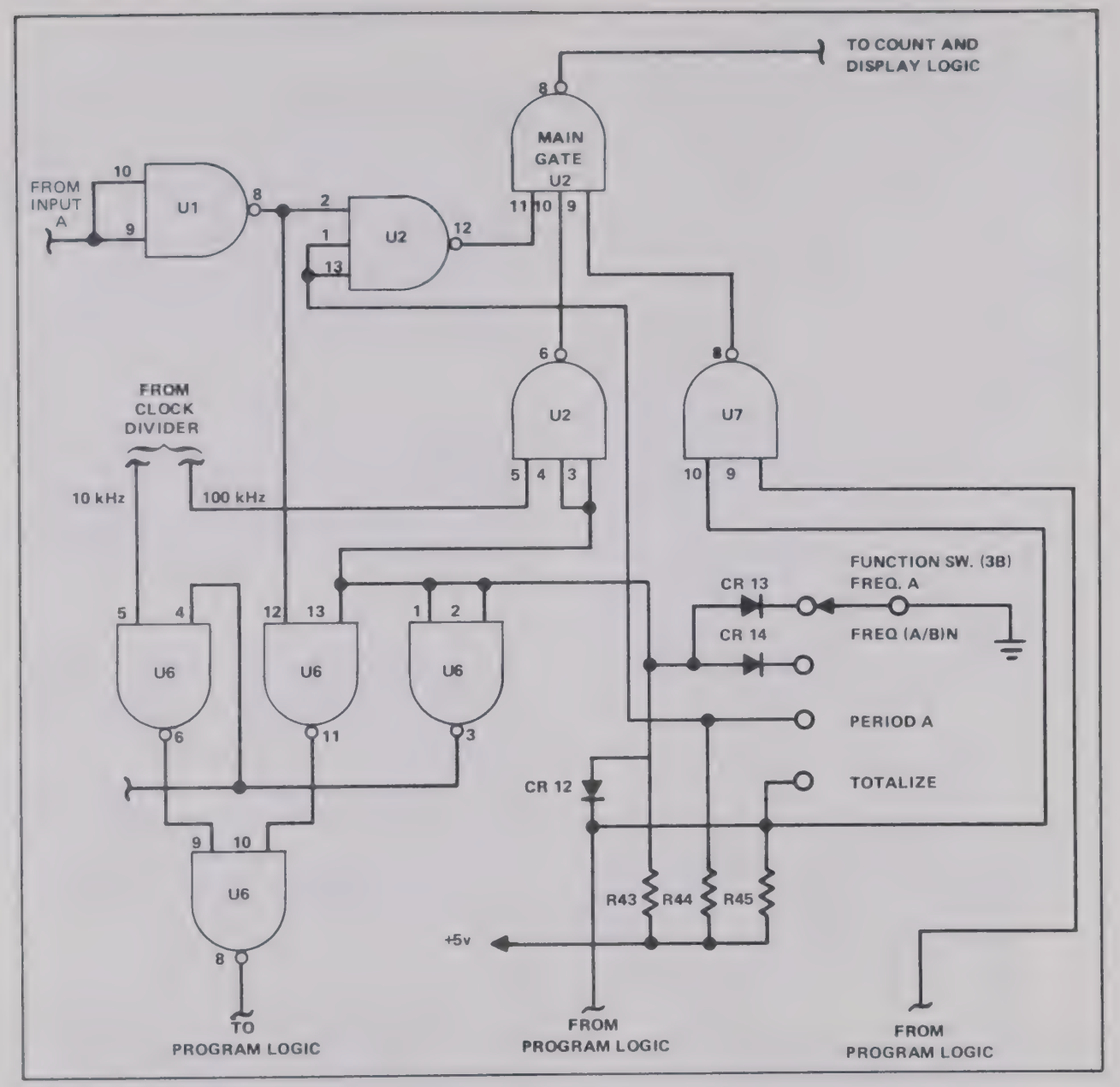


Figure 3-4. INPUT MODE CONTROL

3-19. COUNT AND DISPLAY LOGIC

3-20. Figure 3-6 shows a basic block diagram of the count and display logic. The count input from the main gate, is applied to a high-speed bcd decade counter, capable of counting the 50 MHz direct input signal. The output of this high-speed counter drives the first display IC, and through nand gate U10-3 drives the second (U24) a count and display IC. Four additional count and display IC's (U25-U28) are connected in series to complete the 6 digit display.

3-21. When the input count exceeds the display capacity, the output of the last count and display IC sets the overflow flip-flop. At the end of gate time the M signal from the program logic is applied to the nand gates to energize the overflow indicator. The M signal is also used to update the displayed information of each digit. Figure 3-7 shows the internal configuration of each count and display IC. The first display IC is different, in that it's bcd decade counter is separate. The $\overline{M}$ signal, connected as shown, causes the quad latch to open and accept the count input information from the bcd decade counter.

This count will be displayed until the next cycle when a new input count is admitted by the $\overline{M}$ signal. At the end of every count and display cycle the program logic supplies an $\overline{R}$ signal to reset the bcd decade counter portion of each count and display IC, and reset the over flow flip-flop. At the completion of the reset signal the counter will start a new count and display cycle.

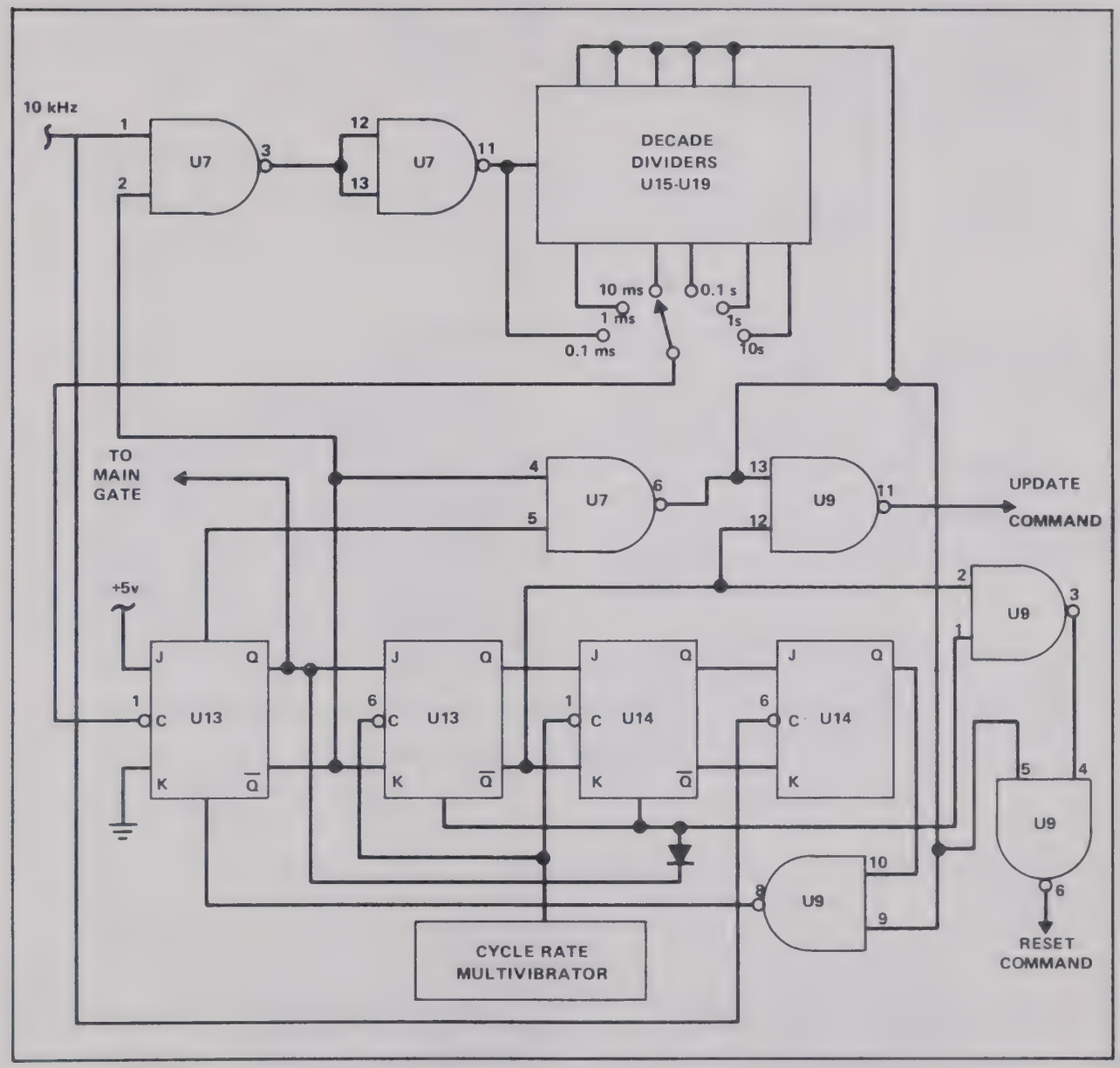


Figure 3-5. PROGRAM LOGIC

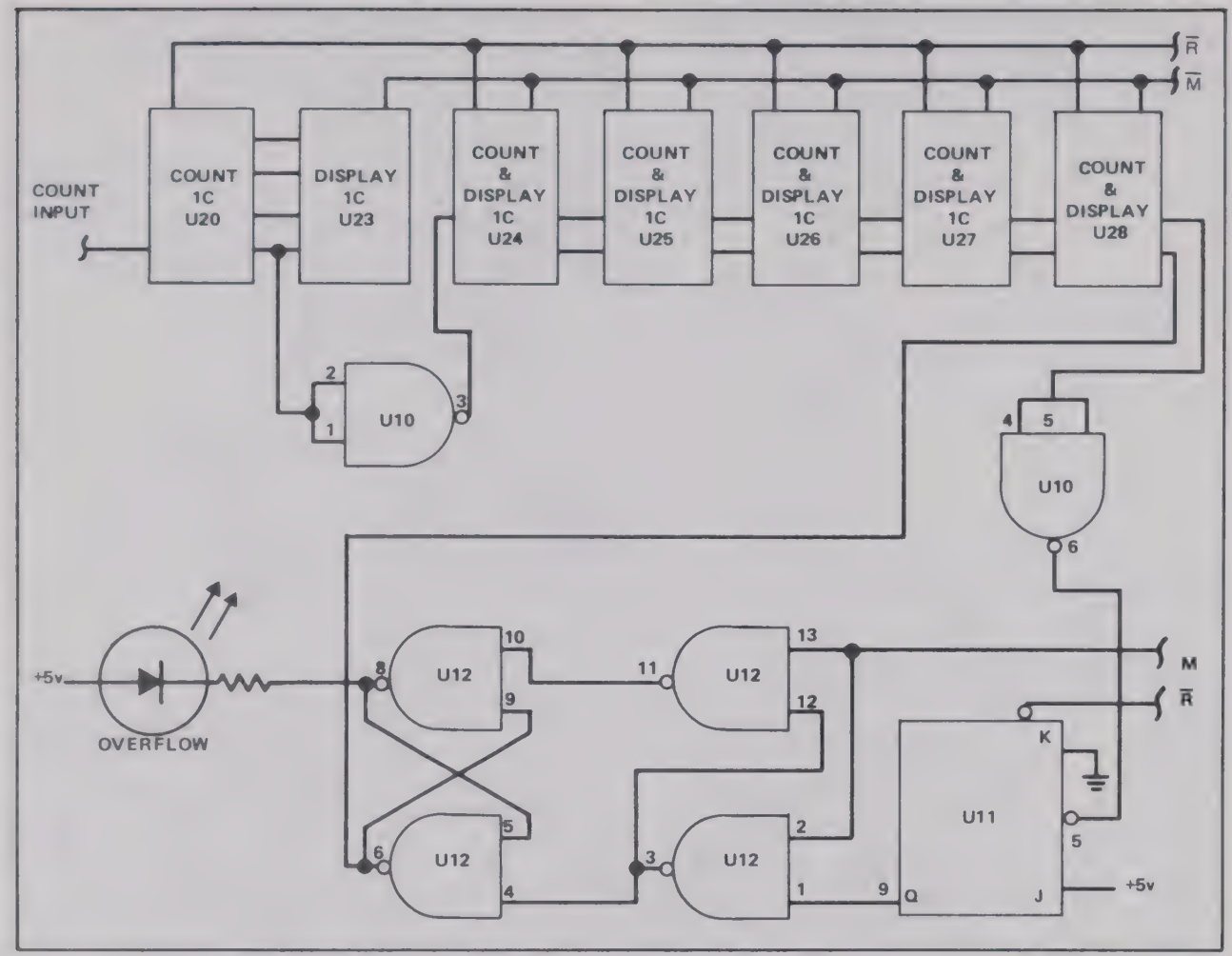


Figure 3-6. COUNT AND DISPLAY LOGIC

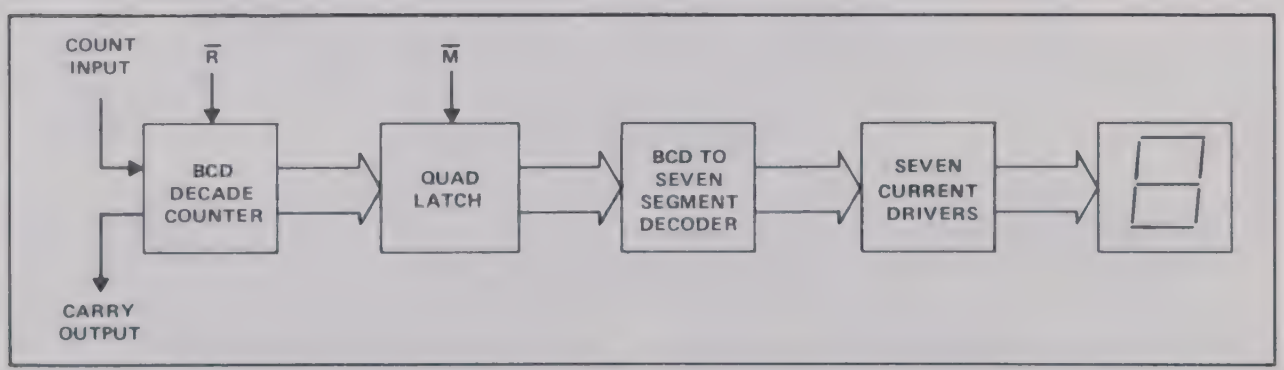


Figure 3-7. COUNT AND DISPLAY 1C INTERNAL CONFIGURATION

Section 4
Maintenance

4-1. INTRODUCTION

4-2. This section contains information and instructions for preventive and corrective maintenance of the model 1950A digital counter. The performance and calibration procedures, are designed to aid in maintaining instrument operation within specifications. Section 3 of this manual is important to the troubleshooting section, since a thorough knowledge of the theory of operation is indispensable in efficient troubleshooting. Maintenance and adjustment instructions, pertaining to model 1950A options can be found in Section 6 of this manual.

4-3. TEST EQUIPMENT

4-4. The equipment recommended for performance testing, calibrating and troubleshooting is listed in Table 4-1. If the recommended model is not available, substitute equipment of similar specifications may be used.

4-5. SERVICE INFORMATION

4-6. All products manufactured by the John Fluke Mfg. Co., Inc. are warranted for a period of one year. Complete warranty information is located in the WARRANTY at the front of the manual.

4-7. Factory authorized calibration and service is available at various world-wide locations. A complete list of Factory Authorized Service Centers is located at the rear of the manual. If requested, an estimate will be provided before repair work is done on an instrument that is beyond the warranty period.

Table 4-1. RECOMMENDED TEST EQUIPMENT

EQUIPMENT TYPE	RECOMMENDED EQUIPMENT	FUNCTION
Multimeter	Fluke Model 8000	Calibration and Troubleshooting
Oscilloscope	Tektronix 465	Troubleshooting
Frequency Standard	10 MHz $\pm 1 \times 10^{-8}$ (1 MHz or 5 MHz may be used)	Calibration, Performance Testing, and troubleshooting
Signal Generator	Wavetek 130 & Tektronix 191	Performance checks, calibration and troubleshooting
Autotransformer	General Radio Variac (W5MT3A)	Performance checks, calibration and troubleshooting

4-8. GENERAL MAINTENANCE

4-9. Cleaning

4-10. This counter should be cleaned periodically to remove dust, grease, or other contaminates. The exterior can be cleaned with a cloth moistened with a mild soap and water solution. Cleaning of the interior sections of the unit should be done using clean, dry air at low pressure. If the contaminates cannot be removed with low pressure air, the interior may be sprayed with Freon T.F. Degreaser (Miller Stephensen Chemical Co. Inc.) to losen the dirt.

4-11. Fuse Replacement

4-12. The line fuse, located in the upper right corner of the rear panel, must be replaced with a fuse rated to match the ac input power configuration. The replacement fuse should be 1 ampere for 115V operation or ½ ampere for 230V operation. The battery fuse, located by the 12V DC INPUT connector, requires a 1 ampere fuse.

4-13. PERFORMANCE TEST

4-14. The following test is intended to evaluate the performance of the 1950A. This test is especially suited to exceptance testing of new instruments. The test should be conducted with ambient temperature at 25°C ± 5°C. The headings given below indicate the particular area in the 1950A circuitry being checked by the individual sections of the performance test.

4-15. Decimal, Digit Blanking and Display Scale Factor

4-16. The following procedure must be done without an input applied.

a. Set the CLOCK INT EXT switch, located on the rear panel, to the INT position.

b. Set the FUNCTION switch to FREQ A.

c. Set the RANGE control and observe the readout as follows in accordance with Table 4-2.

Table 4-2. DECIMAL, DIGIT BLANKING AND SCALE FACTOR CHECK

GATE TIME	DIGIT DISPLAY	SCALE FACTOR
0.1 ms	xxxx.00	MHz
1.0 ms	xxx.000	MHz
10 ms	xx.0000	MHz
0.1 s	xxxx.00	kHz
1.0 s	xxx.000	kHz
10 s	xx.0000	kHz

4-17. Trigger Level, Digits, Reset and Overflow

4-18. In the following procedure an adjustable low frequency signal is used to check each number of each individual significant digit. Each step of the following procedure should be completed in the order given to insure that the trigger level, digits, reset function and overflow indication are properly checked.

a. Rotate the TRIGGER LEVEL control fully clockwise. Note that the + TRIG STAT indicator is illuminated.

b. Rotate the TRIGGER LEVEL control fully counter-clockwise. Note that the – TRIG STAT indicator is illuminated.

c. Check that the transition from + to – occurs at approximately mid range of the TRIGGER LEVEL control.

d. Set the FUNCTION switch to TOTALIZE

e. Set the ATTEN switch to X1

f. Depress the RESET button and note that the display resets to zero (xxxxx0).

g. Adjust the signal generator output to 5 Hz at 50 mV rms.

h. Connect the signal generator to CHANNEL A INPUT.

i. Adjust the TRIGGER LEVEL control for even illumination of the TRIG STAT indicators.

j. Depress the RESET button and note that the counting sequence is correct for the least significant digit.

k. Increase the signal generator frequency slowly, observing the remaining digits for proper counting sequence.

l. After the most significant digit has sequenced up through nine then back to zero, check that the OVERFLOW LED is illuminated.

m. Depress the RESET button and check that the OVERFLOW LED has de-energized.

4-19. Channel B Amplifier and Gate Output

4-20. The symetry of the channel B amplifier output signal is adjustable to insure that the signal level

requirements for the clock divider are met. The output signal symetry and gate output should be checked using the following procedure.

a. Connect an oscilloscope to the EXT CLK out jack (J5) located on the rear panel.

b. Adjust the scope controls as follows:
   1. Vertical control to 2V/cm
   2. Horizontal time base control to .5ms/cm
   3. Trigger source to external.
   4. Trigger slope to positive.

c. Connect a signal generator, set for 1 kHz output at 500 mV, to the EXT CLK connector J2.

d. Place the CLK switch (S2), located on the rear panel, in the EXT position.

e. Set the FUNCTION control to FREQ A.

f. The scope display should be a symetrical, 1 kHz square wave.

g. Place the CLK switch (S2) in the INT position.

h. Set the RANGE switch to 10 ms; FUNCTION to FREQ (A/B)N.

i. Connect an oscilloscope to the GATE OUT connector J6.

j. The scope display should be a positive 10 ms pulse, appearing once each cycle. The CYCLE RATE control will change the time between the gate out pulses.

4-21. Ten MHz Clock and Input Sensitivity

4-22. The ability of the 1950A to accurately display the frequency of an input signal is controlled by the accuracy of the ten MHz clock. The input sensitivity may also affect the accuracy of the counter. The following procedure will determine if the clock frequency and input sensitivity are accurately set.

a. Turn the CYCLE RATE control to midrange.

b. Set the RANGE switch to the 1 s position.

c. Set the FUNCTION switch to FREQ A.

d. Position the TRIGGER LEVEL at midrange.

e. The ATTEN switch should be in the X1 position.

f. Connect a 10 MHz frequency standard to INPUT A.

g. The counter display should be 000.000 ± 1 digit with the OVERFLOW indicator on.

h. Disconnect the frequency standard.

i. Connect a signal generator, set for 50 MHz at 50 mV, to INPUT A.

j. Set the RANGE control to 10 ms.

k. Adjust the TRIGGER LEVEL control for even illumination of the TRIG STAT indicators.

l. Check the display for a stable indication of the 50 MHz input signal frequency.

m. Set the ATTEN switch to the X10 position.

n. The counter display should be XX.0000. (X= unlighted digit)

o. Increase the signal generator output voltage to 500 mV rms.

p. The counter should again accurately display the 50 MHz input signal frequency.

q. Place the ATTEN switch to the X1 position.

4-23. Period A and Frequency (A/B)N Functions

4-24. The counters ability to properly process an input signal in the PERIOD A or FREQ (A/B)N function can be checked using the following procedure.

a. Set the FUNCTION control to PERIOD A.

b. Set the RANGE control to 10^5 PER AVGD (listed in yellow)

c. Connect a signal generator, set for 20 kHz at 50 mV rms, to INPUT A.

d. The counter display shoule be 50.0xxx μs. Adjust the TRIGGER LEVEL if necessary.

e. Set the RANGE control and check the display in accordance with table 4-3.

Table 4-3. PERIOD A DISPLAY CHECK

PER AVGD	DIGIT DISPLAY	SCALE FACTOR
10^5	50.0XXX	μs
10^4	X50.0XX	μs
10^3	XX50.0X	μs
10^2	XX.0500	ms
10^1	XXX.050	ms
10^0	XXXX.05	ms

f. Disconnect the signal generator from INPUT A.

g. Using a T connector, attach the signal generator output to both INPUT A and INPUT B.

h. Set the RANGE control to 0.1 ms.

i. Adjust the signal generator output for 1 kHz at 500 mV rms.

j. The counter display should be XX10.00.

k. Increase the signal generator output level to 10V rms and the display should be as indicated in step j.

l. Reset the signal generator controls for 10 MHz at 500 mV rms.

m. The counter display should again be XX10.00.

4-25. TROUBLESHOOTING

4-26. The following information is provided to assist in locating malfunctions in the model 1950A. It is recommended that the theory of operation in Section 3 be read completely before attempting any troubleshooting.

4-27. Initial Troubleshooting

4-28. The troubleshooting techniques given below should be completed as the first step toward repairing any apparent malfunction in the counter. Improper counter operations may not be caused by malfunctions within the 1950A. The following reminders of basic fault isolation will help determine if the cause is the result of an internal malfunction or faulty external connections.

a. Carefully check the 1950A control settings: some false indications may be caused by an incorrect or overlooked control setting.

b. Check associated equipment: insure the associated equipment controls and connections are correct.

c. Check the 1950A performance: the performance test (paragraph 4-13) will determine if the malfunction is in the counter.

d. Carefully inspect the interior of the instrument: Check for physically damaged parts, lose or broken wires and improperly seated plug-in assemblies.

4-29. When it is determined, by the above checks, that the malfunction is within the 1950A counter the following procedure should be used to isolate the problem area. The recommended test equipment for troubleshooting this instrument is listed in table 4-1.

4-30. Power Supply Check

4-31. Incorrect output voltages from either the +10 volt or +5 volt power supply may cause the counter to exhibit various improper indications. Because of this, the power supply voltages should be checked in the event of any counter malfunction. Use the following procedure to check the +10 volt and +5 volt power supplies.

a. Connect the voltmeter common to counter ground.

b. Connect the voltmeter high input to the +10 volt power supply output. (See parts location drawing, 1950A-1201, TP2). The voltage output should be +8.7 to +9.8 volts.

c. Connect the voltmeter high input to the +5 volt power supply output (See parts location drawing, 1950A-1201, TP1). The voltage output should be +4.85 $\pm$ 0.5 volts.

4-32. If either power supply is found to be out of tolerance, refer to the 1950A-1001 schematic, power supply section. This schematic is located at the back of this manual.

4-33. Fault Area Isolation

4-34. A malfunction in the 1950A may be isolated to a particular section of the circuitry by observing the counter display during each mode of operation. Figure 4-1 illustrates how each of the four counter functions combines various sections of circuitry to process the input signals. The sections of circuitry common to the inoperative functions are the most likely location of the malfunction. Refer to Section 2 for operating instructions for each function. The performance test also exercises individual circuits and may provide additional information that can be used to isolate the malfunction.

4-35. The fault area may be identified by noting the counter functions (FREQA, FREQ (A/B)N, PERIOD A and TOTALIZE) that operate correctly and those that are inoperative. Table 4-4 gives the probable fault area indicated by three different functional test results. The paragraphs that follow the table include additional information that may further isolate the fault area.

4-36. The performance tests in Section 4 check the operation of smaller section of the counter circuits. The list of specific sections of counter circuitry and the paragraph number of the performance test that will check the operation of each circuit may help point out the fault area.

a. Perform the tests of paragraph 4-15 if any of the following occur.

1. Improper decimal display

2. Incorrect digit blanking (Leading zero suppression)

3. Improper scale factor display

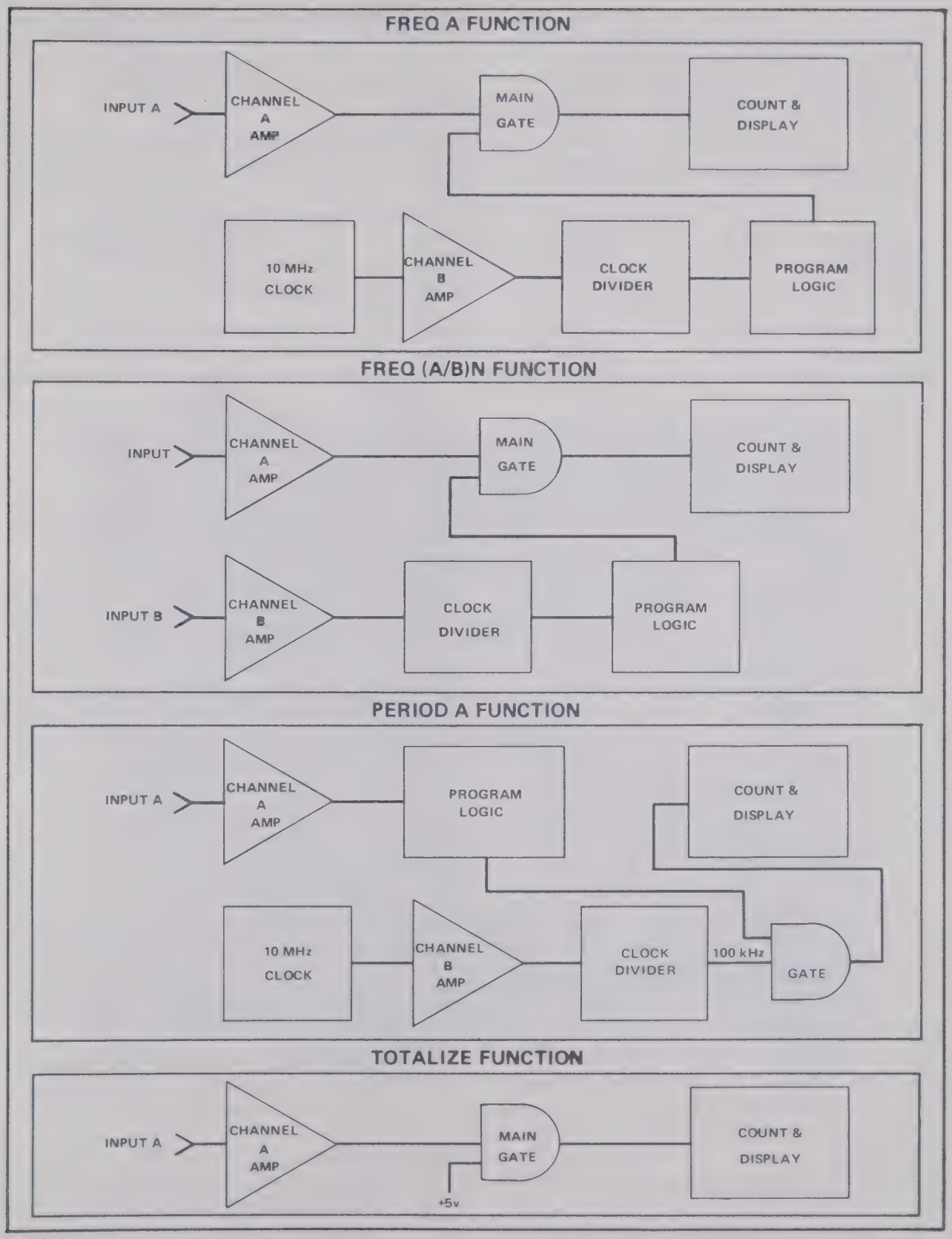


Figure 4-1. FUNCTIONAL BLOCK DIAGRAMS

Table 4-4. FAULT AREA IDENTIFICATION

FUNCTION				FAULT AREAS INDICATED
FREQ A	FREQ (A/B)N	PERIOD A	TOTALIZE	
improper operation	proper operation	improper operation	proper operation	10 MHz CLOCK
improper operation	improper operation	improper operation	proper operation	CHANNEL B AMP, CLOCK DIVIDER or PROGRAM LOGIC
improper operation	improper operation	improper operation	improper operation	DISPLAY, MAIN GATE or CHANNEL A AMP

b. Perform the tests of paragraph 4-17 if any of the following occur.

1. Improper trigger level; excessive amplitude of the input signal required to cause counting.
2. Incorrect digits displayed
3. Incorrect overflow indication
4. Incorrect display reset; manual or automatic

c. Perform the tests of paragraph 4-19 if the channel B amplifier is the suspected fault area.

d. Perform the tests in paragraph 4-21 if any of the following occur.

1. The 10 MHz clock is the suspected fault area
2. The input sensitivity of channel A is incorrect

4-37. CALIBRATION

4-38. The 1950A should be calibrated every six months, or whenever repairs have been made. The calibration adjustment locations are shown in Figure 4-2.

4-39. Clock Oscillator Adjustment

4-40. The clock oscillator 10 MHz output frequency can be accurately set using either method listed below. The first method described should be used when a frequency standard is available, and the alternate method may be used when a frequency standard is not available.

4-41. Oscillator Adjustment Using a Frequency Standard

4-42. Before performing the following procedure insure that the frequency standard is up to operating temperature to insure proper accuracy of the timebase oscillator.

a. Connect the output of the frequency standard to the CHANNEL A input connector of the counter. The frequency standard output should be at least 100 mV in amplitude and 1 MHz or greater in frequency.

b. Adjust the Model 1950A controls as follows:

CYCLE RATE . . . . . midrange
RANGE . . . . . 10 ms
TRIGGER LEVEL for even illumination of the + and – status indicators

The counter will display the frequency standards output in MHz with display resolution to 1 kHz.

c. Set the RANGE switch to 10s. The display will indicate the input in kHz, resolved to 0.1 Hz, and the overflow indicator will be illuminated.

d. Adjust the timebase oscillator frequency adjustment, for a counter display within 0.5 Hz of the output frequency of the frequency standard. The frequency adjustment is located as shown on Figure 4-2.

4-43. Oscillator Adjustment Using a Shortwave Receiver

4-44. This procedure requires the counter to be

4-44. This procedure requires the counter to be in close proximity to the receiver antenna lead in cable.

a. Remove the top and bottom covers of the 1980A counter.

b. Tune the SW receiver to the 10 MHz WWV broadcast.

c. Bring the 1950A near enough to the SW receiver antenna lead so that a zero beat note can be heard on the receiver speaker. If insufficient radiation is picked up from the counter, turn the timebase oscillator towards the antenna and move it in close.

d. Tune the 1950A timebase oscillator adjust for a zero-beat on the receiver.

e. Look at the receiver signal level meter, and adjust the timebase for an exact null. This will put the timebase oscillator output frequency within 1 Hz of the 10 MHz requirement.

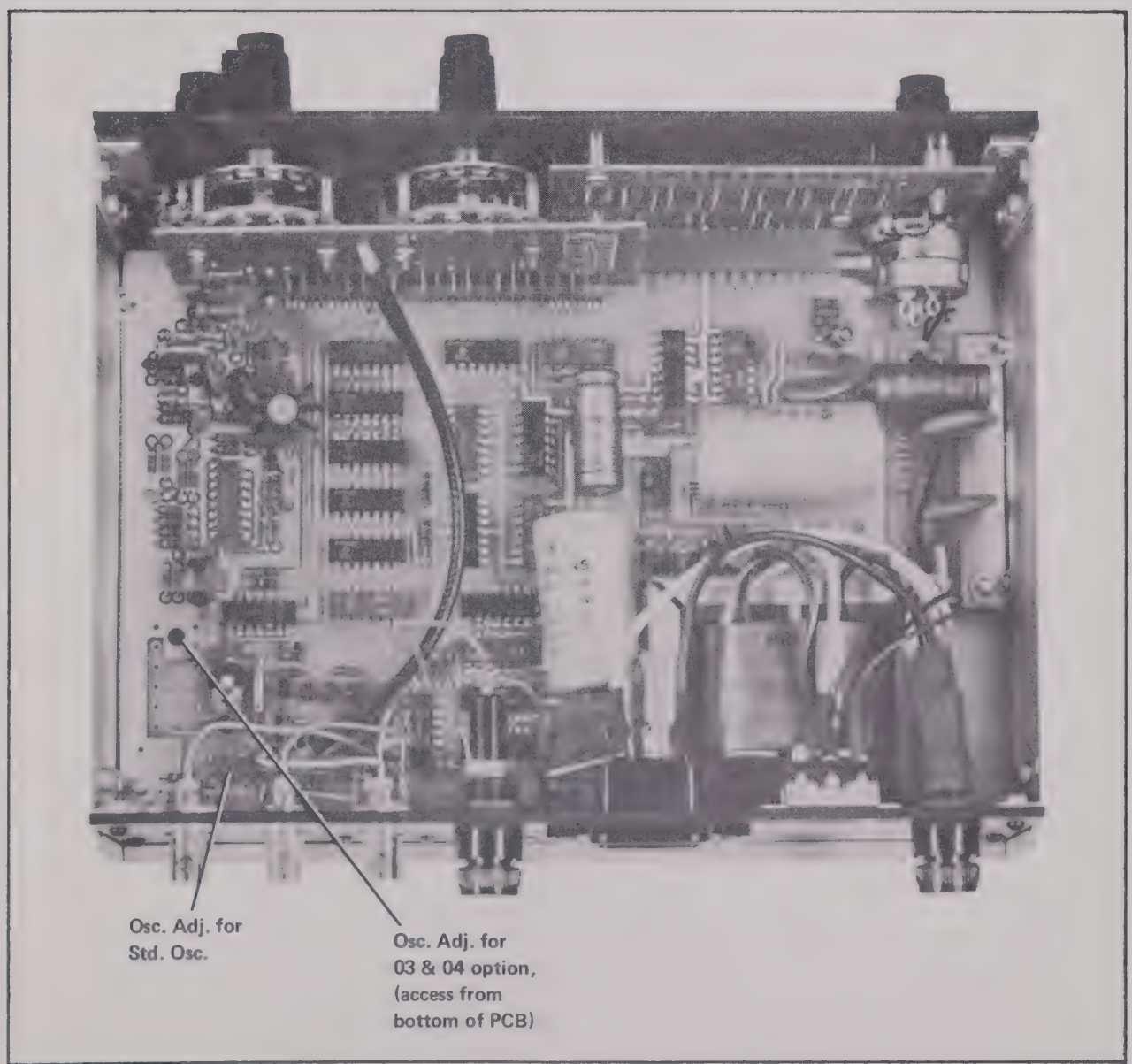


Figure 4-2. CALIBRATION ADJUSTMENT LOCATIONS

Section 5
Lists of Replaceable Parts

ASSEMBLY NAME	PART NO.	PAGE
Digital Counter	1950A	5-4
Main Assembly	371278	5-6
Switch Assembly	371260	5-11
Front Panel Assembly		5-12
Display Assembly	371302	5-13

5-1. INTRODUCTION

5-2. This section of the manual contains a listing of replaceable components for this instrument. The first listing contains a complete breakdown of all the major assemblies followed by subsequent listings that itemize the components on each major assembly. An illustration accompanies each major assembly listing to aid in locating the listed components.

5-3. COLUMN DESCRIPTION

a. The REF DESIG column indexes the item description to the associated illustration. In general the reference designations are listed under each assembly in alpha-numeric order. Subassemblies of minor proportions are sometimes listed with the assembly of which they are a part. In this case, the reference designations for the components of the subassembly may appear out of order.

b. The DESCRIPTION column describes the salient characteristics of the component. Indention of the description indicates the relationship to other assemblies, components, etc. In many cases it is necessary to abbreviate in this column. For abbreviations and symbols used, see the following page.

c. The six-digit part number, by which the item is identified at the John Fluke Mfg. Co., is listed in the STOCK NO. column. Use this number when ordering parts from the factory or authorized representatives.

d. The Federal Supply Code for the item manufacturer is listed in the MFR column. An abbreviated list on Federal Supply Codes is included in the Appendix.

e. The part number which uniquely identifies the item to the original manufacturer is listed in the MFR PART NO. column. If a component must be ordered by description, the type number is listed.

f. The TOT QTY column lists the total quantity of the items used in the instrument and reflects the latest Use Code. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument or are deviations from the basic instrument model, the TOT QTY column lists the total quantity of the item in that particular assembly.

g. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

h. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of an instrument. Each part for which a Use Code has been assigned in the basic instrument may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List, Paragraph 5-9. Each additional option printed circuit assembly has also been assigned a serial number unique to that particular option. The changes and Serial Number Effectivity List for these printed circuit board assemblies are located in their respective Section 6 option subsection. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used wherever possible. Standard components may be ordered directly from the manufacturer by using the manufacturer's part number, or parts may be ordered from the John Fluke Mfg. Co. factory or authorized representative by using the Fluke part number. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. You can insure prompt and efficient handling of your order to the John Fluke Mfg. Co. if you include the following information:

a. Quantity.

b. FLUKE Stock Number.

c. Description.

d. Reference Designation.

e. Instrument model and serial number.

Example: 2 each, 177105, Transistors, 2N3565, Q107-108 for 845AR, s/n 168.

5-7. If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part, showing its location to other parts of the instrument, is usually most helpful.

5-8. SERIAL NUMBER EFFECTIVITY

5-9. A Use Code column is provided to identify certain parts that have been added, deleted, or modified during production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity List below. However, these Use Codes and Serial Numbers apply only to the basic configuration. All parts with no Use Code are used on all instruments with serial numbers 123 and above. For additional option printed circuit board changes and serial number assignments, see the respective Section 6 option subsection.

DIGITAL COUNTER 5 Hz TO 50 MHz

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DIGITAL COUNTER 5 Hz TO 50 MHz Figure 5-1.	1950A	89536				
	Main PCB Assembly (See Figure 5-2)	371278	89536	371278	1		
	Switch Assembly (See Figure 5-3)	371260	89536	371260	1		
	Front Panel Assembly				1		
	Display Assembly (See Figure 5-4)	371302	89536	371302	1		
C17	Cap, var.	369207	25403	C010/HT10	1		
C18	Cap, cer, 22 pf ±20%, 500V	369157	72982	831 000-C0G0220	1		
C19	Cap, cer, 47 pf ±20%, 1000V	369132	56289	C030B10 2H470J	1		
F1	Fuse, fast-blow, 1 amp	367819	71400	AGG	1		
F2	Fuse, fast-blow, 2 amp	109173	71400	AGC	1		
Q11	Xstr, T1P32	369660	89536	369660	1		
R58	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		
T1	Xfmr, power	370494	89536	370494	1		
XF1, XF2	Fuse holder	100107	71400	HKP	2		
Y1	Crystal, 10 MHz	369774	02533	ADR10	1		
	Bail	370627	89536	370627	1		
	Bracket, left	371211	89536	371211	1		
	Bracket, right	371229	89536	371229	1		
	Cover, BCD	367508	89536	367508	1		
	Cover, bottom	365288	89536	365288	1		
	Cover, top	365270	89536	365270	1		
	Decal, rear panel	375436	89536	375436	1		
	Decal, title	363622	89536	363622	1		
	Foot, left	369843	21604	PP40012-1	1		
	Foot, right	369850	21604	PP40012-2	1		

DIGITAL COUNTER 5 Hz to 50 MHz

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	Foot, rear	369835	21604	PP40013	2		
	Knob Assembly	365007	89536	365007	1		
	Knob Assembly	341420	89536	341420	1		
	Knob Assembly	341453	89536	341453	2		
	Line cord, connector	343723	70903	KH704	1		
	Receptacle, BNC	152033	zzzzz	30355-1	3		

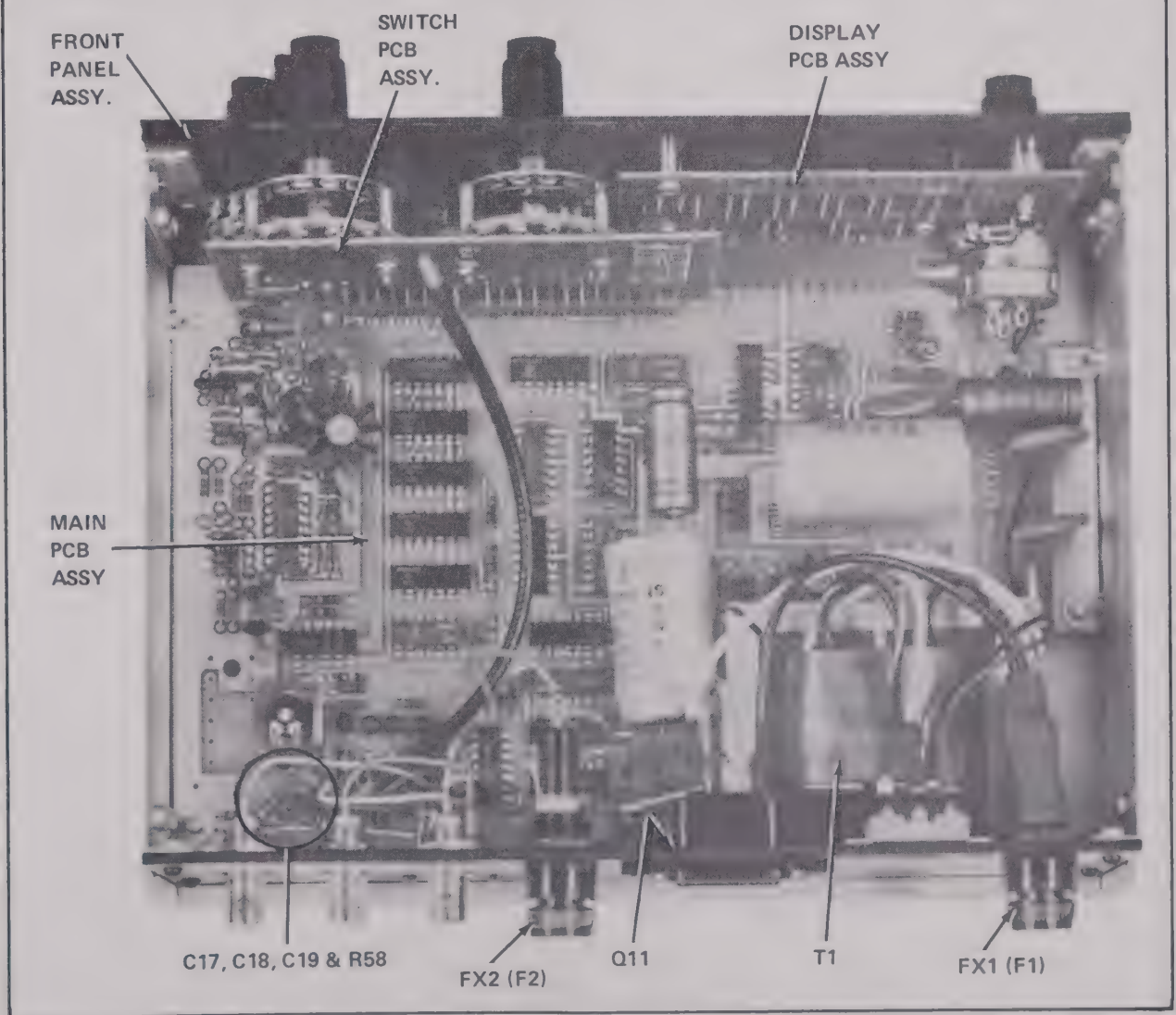


Figure 5-1. 1950A DIGITAL COUNTER

MAIN ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	MAIN ASSEMBLY **Figure 5-2.**	1950A-4001	89536	371278	REF		
C1, C2, C7	Cap, mylar, .022 uf ± , 630V	369165	25403	C280MAF 22K	3		
C3	Cap, mini-cer, 15 pf ± , 100V	369074	32897	8111-A100-C0G-150G	1		
C4	Cap, mica, 240 pf ±5%, 500V	362863	14655	CD15FD241 J03	1		
C5, C31, C33, C34	Cap, cer, .01 uf +100/–20%, 50V	369579	72982	8121-A050-651-103Z	4		
C6, C15, C16	Cap, cer, 22 pf ±20%, 500V	369157	72982	831-000C0G 0220	3		
C8, C9, C10, C12, C13, C14, C25, C26	Cap, Ta, 10 uf ±20%, 15V	193623	56289	196D106X0015 JA1	8		
C11, C27	Cap, elect, 22 uf ±10%, 25V	241356	73445	ET220X025A7	2		
C17, C18, C19	See Digital Counter 5 Hz to 50 MHz						
C20, C21	Cap, cer, .005 uf ±20%, 3kV	188003	71590	2DDH6R502M	2		
C22, C23	Cap, elect, 5000 uf +100/–10%, 10V	379370	25088	B41010/5000/1S	2		
C24, C29	Cap, elect, 220 uf ±40%, 25V	369181	34553	ET221X025A00	2		
C28	Cap, cer, 0.1 uf ±GMV 50V	369561	1	HCC50104P	1		
C30	Cap, cer, 680 pf ± %, 100V	375857			1		

MAIN ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8, CR12, CR39, CR49, CR50, CR51, CR52	Diode, Si, high speed switching	364224	04713	IN914	14		
CR9, CR48	Diode, zener	159798	07910	IN751	2		
CR10, CR11							
CR13 thru CR26	See Switch PCB Assembly						
CR29	Not used						
CR40, CR41, CR42, CR43							
CR44, CR45, CR46,	Diode, Si, Rect.	368738	04713	IN4004	7		
CR47	Diode Zener	180406					
Q1	Xstr, FET	369637	01295	2N5951	1		
Q2,Q9	Xstr, FET	288324	01295	2N5245	2		
Q3,Q5	Xstr	369603	01295	2N4257	2		
Q4, Q7, Q8	Xstr	369629	01295	2N5771	3		
Q6	Xstr	369645	07263	2N4274	1		
Q10	Xstr	369686	07263	2N697	1		
Q12, Q13, Q14	Xstr	369678	01295	TIS98	3		
R1	Res, comp, 1.8M ±5% ¼W	289629	01121	CB1855	1		
R2	Res, comp, 1M ±5%, ¼W	182204	01121	CB1055	1		

MAIN ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R3	Res, comp, 82k ±5%, ¼W	188458	01121	CB8235	1		
R4, R17, R22, R27, R28, R46 R71	Res, comp, 560 ±5%, ¼W	147991	01121	CB5615	7		
R6	Res, comp, 180 ±5%, ¼W	147942	01121	CB1815	1		
R7	Res, comp, 120k ±5%, ¼W	179598	01121	CB1245	1		
R8, R62	Res, comp, 220 ±5%, ¼W	147959	01121	CB2215	2		
R9	Res, comp, 10M ±5%, ¼W	194944	01121	CB1065	1		
R10, R64	Res, comp, 100k ±5%, ¼W	148189	01121	CB1045	2		
R11, R13, R14, R20, R37, R42, R43, R44, R45, R67, R68, R69	Res, comp, 1k ±5%, ¼W	148023	01121	CB1025	12		
R12	Res, var, 10k	369553			1		
R15	Res, comp, 100 ±5%, ¼W	147926	01121	CB1015	1		
R16	Res, comp, 22 ±5%, ¼W	147884	01121	CB2205	1		
R18, R23, R26, R29, R30, R35, R36, R63, R70	Res, comp, 2.2k ±5%, ¼W	148049	01121	CB2225	9		
R19	Res, comp, 5.6k ±5%, ¼W	148080	01121	CB5625	1		
R21	Res, comp, 1.2k ±5%, ¼W	190371	01121	CB1225	1		
R25	Res, comp, 6.8k ±5%, ¼W	148098	01121	CB6825	1		

MAIN ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R31, R32	Res, comp, 390 ±5%, ¼W	147975	01121	CB3915	2		
R33, R34	Res, comp, 820 ±5%, ¼W	148015	01121	CB8215	2		
R38	Res, comp, 270 ±5%, ¼W	160804	01121	CB2715	1		
R39	Res, comp, 150 ±5%, ¼W	147934	01121	CB1515	1		
R40, R41	Res, comp, 82 ±5%, ¼W	149484	01121	CB8205	2		
R59, R61	Res, comp, 680 ±5%, ¼W	148007	01121	CB6815	2		
R60	Res, comp, 39 ±10%, ¼W	188490	01121	EB3901	1		
R65	Res, comp, 8.2k ±5%, ¼W	160796	01121	CB8225	1		
U1, U9	IC, TTL, Quad 2-Input POS NAND Gate	293068	01295	SN74H00N	2		
U2	IC, Digital gate	369728					
U3, U4, U5, U15, U16, U17, U18, U19	IC, MSI Decade Counter	293159	01295	SN7490N	8		
U6, U7, U8, U10, U12	IC, TTL, Quad 2-Input NAND Gate	292953	01295	SN7400N	5		
U11, U14	IC, Digital, Dual JK Master Slave Flip-Flop	368571		7434	2		
U13	IC, TTL, Digital Flip-Flop	369694			1		
U20	IC, TTL, 50 MHz Decade counter	320754	01295	SN74196N	1		
U21	IC, Linear	375790	12040	LM309H	1		
U22	IC,	369702	04713	MC10116L	1		
	Heat Sink	104646	05820	207AB	1		
	Transipad	152207	zzzzz	10123DAP	2		

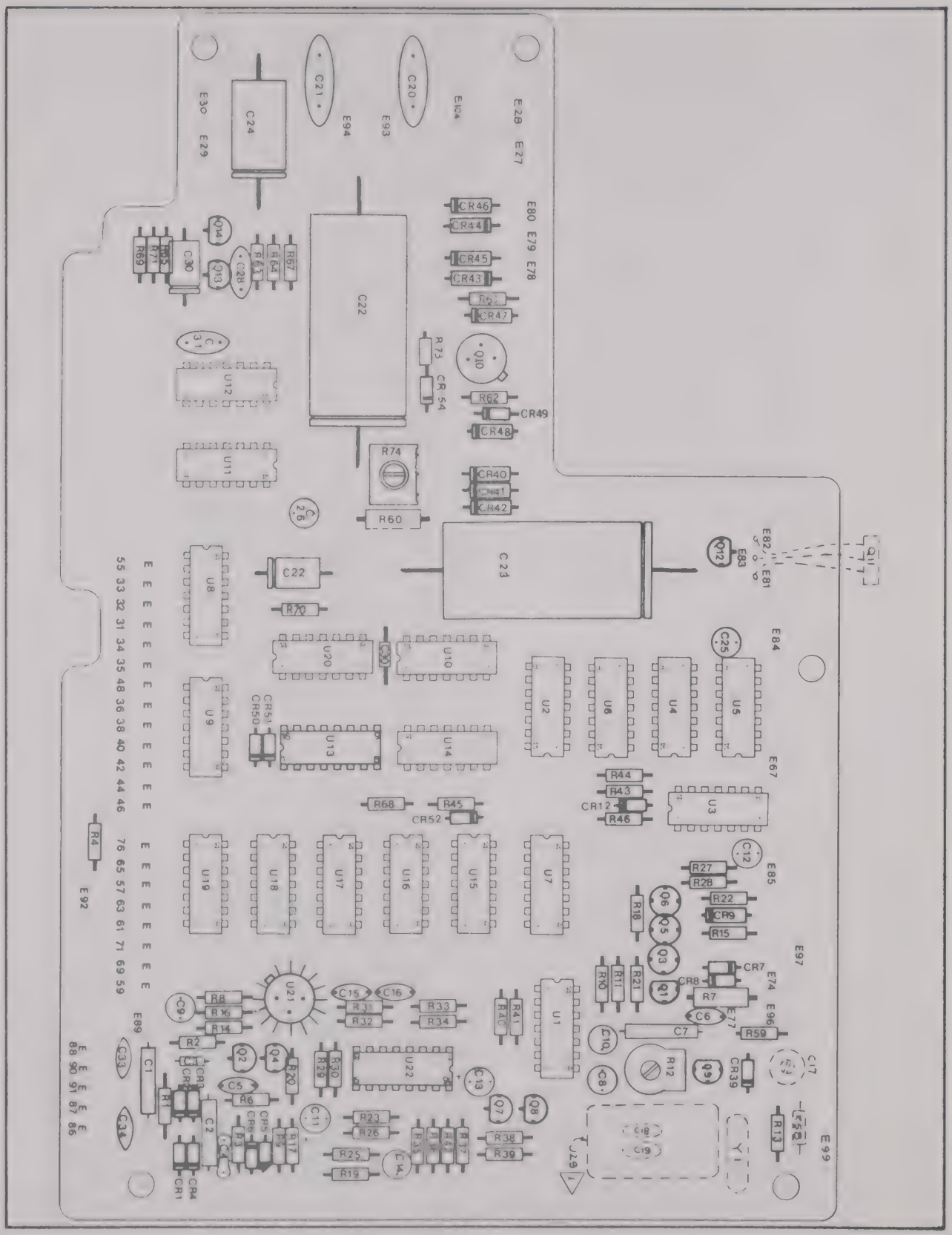


Figure 5-2. MAIN ASSEMBLY

SWITCH ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	SWITCH ASSY **Figure 5-3.**	371328	89536	371328	REF		
CR10, CR11	Diode LED	369777	28480	5082-4480	2		
CR13 thru CR26	Diode, fast switching	289595	07910	1N4148	14		
R5	Res, comp, 220 ±5%, ¼W	147959	01121	CB2215	1		
S3	Switch, functional	370346	89536	370346	1		
S6	Switch, Range	370338	89536	370338	1		
	Connector pin	370262	91662	62-5101-4333-00-11	21		

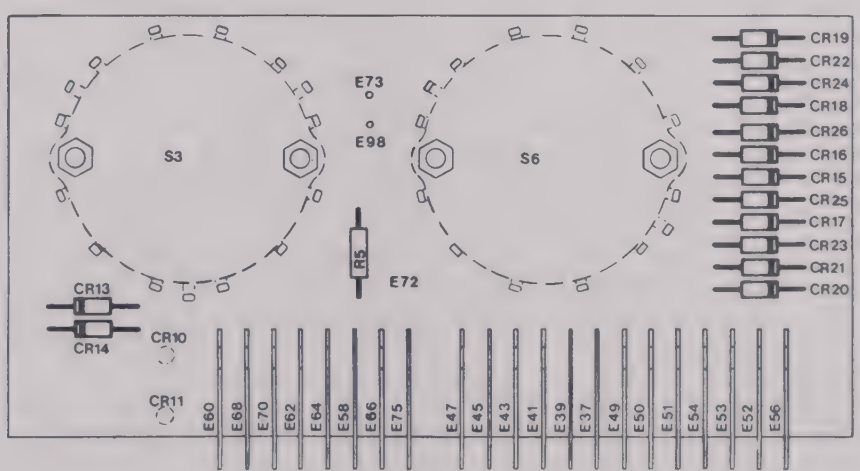


Figure 5-3. SWITCH ASSEMBLY

FRONT PANEL ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FRONT PANEL ASSEMBLY	371336	89536	371336	1		
	Display Assembly Figure 5-	371294	89536	371294	1		
R24	Res, var, 10k ±30%, ½W	370239	71450	CTS450	1		
	Connector, coax	152033	zzzzz	30355-1	2		
	Front panel plstc	371187	89536	371187	1		
	Heat sink	371203	89536	371203	1		
	Tape, 3/8 in.	331249	3M	X-1140	AR		

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DISPLAY ASSEMBLY **Figure 5-4.**	1950A-4002	89536	371302	REF		
C32	Cap, Ta, 10µf ±20%, 15V	193623	56289	196D106X0015JA1	1		
CR27, CR28, CR30, CR31, CR53	Diode, LED	369777	28480	5082-4480	5		
CR33 thru CR38	Diode, fast switching	289595	07910	1N4148	8		
J1	Connector	369884			1		
R47, R48, R49	Res, comp, 330 ±5%, ¼W	147967	01121	CB3315	3		
R50, R51, R72	Res, comp, 82 ±5%, ¼W	149484	01121	CB8205	3		
R52 thru R57	Res, comp, 470 ±5%, ¼W	147983	01121	CB4715	6		
R66-S4	Res, var, switch, 100k	370254	89536	370254	1		
S7	Switch, SPST	370353	09353	8532	1		
U23	IC	369793	01295	L308	1		
U24 thru U28	IC	369785	01295	L306	1		

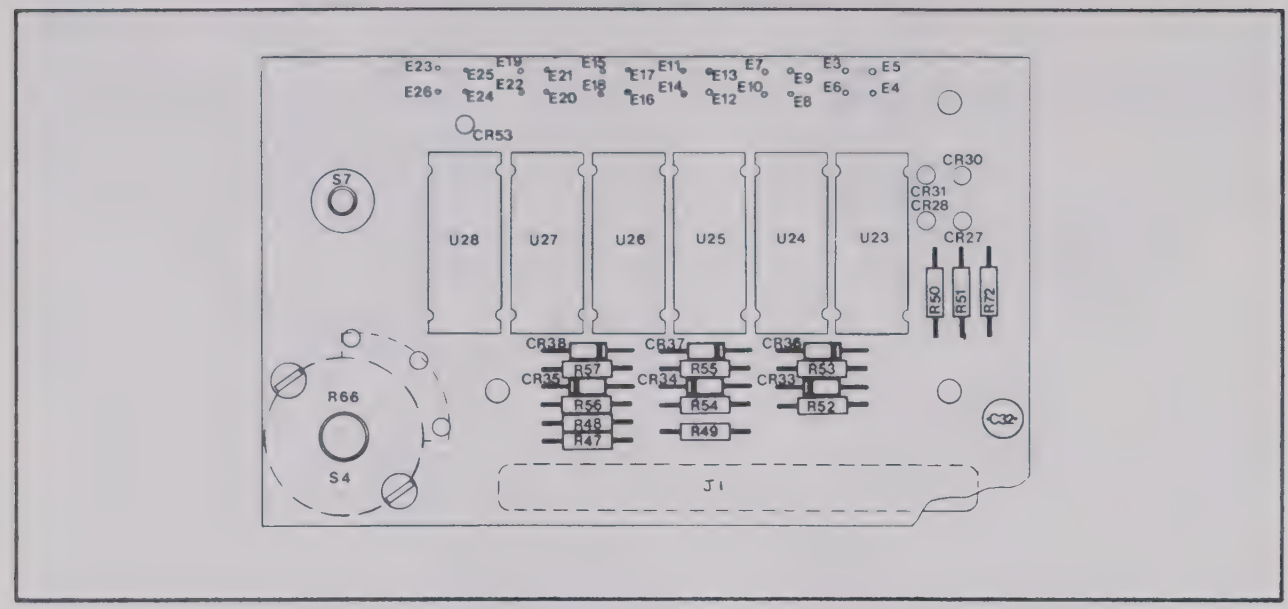


Figure 5-4. DISPLAY ASSEMBLY

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information pertaining to the accessories and options available for your instrument.

6-3. OPTION INFORMATION

6-4. Each of the options available for this instrument, if any, are described separately under headings containing the option number. The option descriptions contain applicable operating and maintenance instructions and field installation procedures for the field installation options. A complete list of replaceable parts for each option is contained at the end of that option description.

6-5. ACCESSORY INFORMATION

6-6. The accessory information, if applicable, will contain details concerning accessories that may be used with this particular instrument.

Option–02
BCD Output

6-1. INTRODUCTION

6-2. The BCD Output is installed as the –02 option. This option can be installed at the factory during manufacture or later in the field, as desired. The field installation kit for the BCD Output is identified as the 1950A-02K.

6-3. INSTALLATION

6-4. Use the following procedure when installing the BCD Output option -02 in the 1950A.

a. Disconnect the line power cord from the unit.

b. Remove the top dust cover.

c. Remove the cover from the BCD output opening in the rear panel of the counter and retain the screws.

d. Pass the wire leads through the BCD output opening, from the rear, and fit the connector into the opening.

e. Secure the connector to the rear panel using the two screws removed in step c.

6-5. The internal connections must be made properly in order to obtain correct information from the BCD output connector. The following procedure must be used when installing the BCD output option. Table 6-1 lists the display assembly connection point for each BCD output connector pin. Steps e through h are a step-by-step example of the first four connections to be made in Table 6-1. Make the remaining indicated connection in the order given.

a. Solder the violet wire (BCD output connector pin 18) to the M signal pad, located on the main assembly pcb near the display assembly connector J1.

b. Solder the green wire (BCD output connector pin 36) to a ground connection pad in the left rear corner of the main assembly pcb.

c. Solder the blue wire (BCD output connector pin 15) to the R signal pad, located on the main assembly pcb near the display assembly connector J1.

d. Solder the white wire (BCD output connector pin 3) to the OF signal pad, located on the main assembly pcb near the display assembly connector J1.

e. Solder the gray wire, attached to pin 20 of the output connector, to BCD Signal connection E26 (refer to the Display Assy Parts Location drawing Figure 5-)

NOTE!

The parts location drawing is a view of the display assembly from the front of the counter. The BCD connections are made to the back of the pcb; care must be taken when identifying the BCD connections.

f. Solder the brown wire, attached to pin 19 of the output connector, to BCD signal connection E23.

g. Solder the red wire, attached to pin 1 of the output connector, to BCD signal connection E24.

h. Solder the yellow wire, attached to pin 2 of the output connector, to BCD signal connection E25.

i. Make each remaining connection in the order given in Table 6-1.

j. Using a multimeter, check continuity from the connector pin to the corresponding internal connection point.

k. Clamp the BCD output connector wires into a bundle using the three cable clamps provided.

l. Replace the top dust cover.

6-6. To check the performance of the -02 option, connect the BCD output to a remote display and complete Performance Test, Section 4, paragraph 4-18 step d through m.

Table 6-1. BCD OUTPUT CONNECTIONS

BCD OUTPUT CONN. PIN	WIRE COLOR	DISPLAY ASSY. SIGNAL CONN.
20	gray	E26
19	brown	E23
1	red	E24
2	yellow	E25
23	gray	E22
22	brown	E19
4	red	E20
5	yellow	E21
26	gray	E18
25	brown	E15
7	red	E16
8	yellow	E17
29	gray	E14
28	brown	E11
10	red	E12
11	yellow	E13
32	gray	E10
31	brown	E7
13	red	E8
14	yellow	E9
35	gray	E6
34	brown	E3
16	red	E4
17	yellow	E5

Option–03
1950A-03 TCXO

6-1. INTRODUCTION

6-2. The 03 option provides an added measure of stability and accuracy over the operating temperature range of the counter. The specifications for this option are located in Section 1 of this manual. Figure 6-1 illustrates the difference between the temperature coefficient of the standard oscillator and that of the –03 and –04 options.

6-3. CALIBRATION

6-4. The calibration of the -03 option is the same as that of the standard oscillator. Refer to Section IV for the clock calibration.

Option–04
1950A-04 TCXO

6-1. INTRODUCTION

6-2. The 04 option is a Temperature Controlled Crystal Oscillator that reduces the temperature dependence of the counter to its lowest possible level. The relationship of the temperature dependence of the oscillators is illustrated in Figure 6-1.

6-3. CALIBRATION

6-4. The calibration of the -04 option is the same as that of the standard oscillator. Refer to Section IV for the clock calibration.

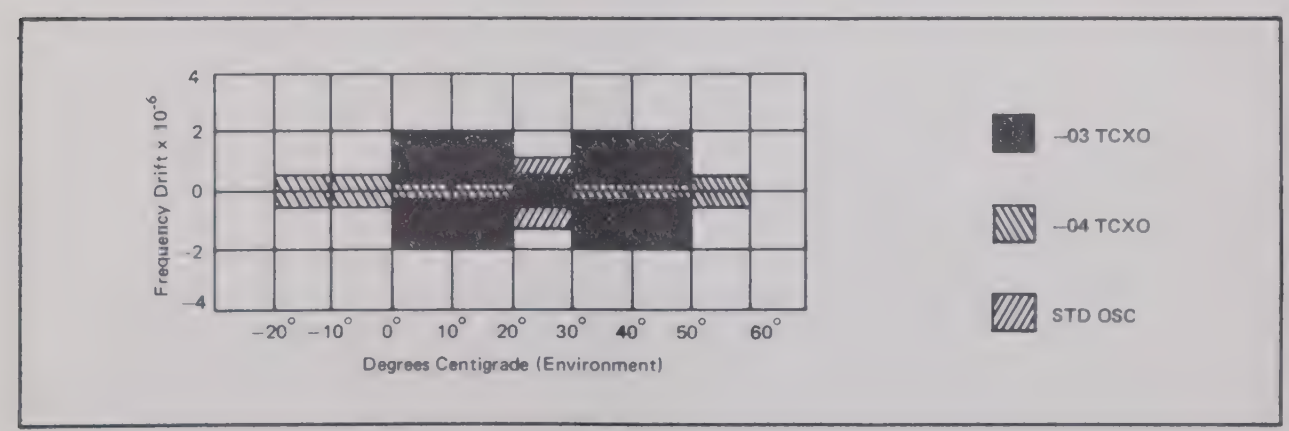
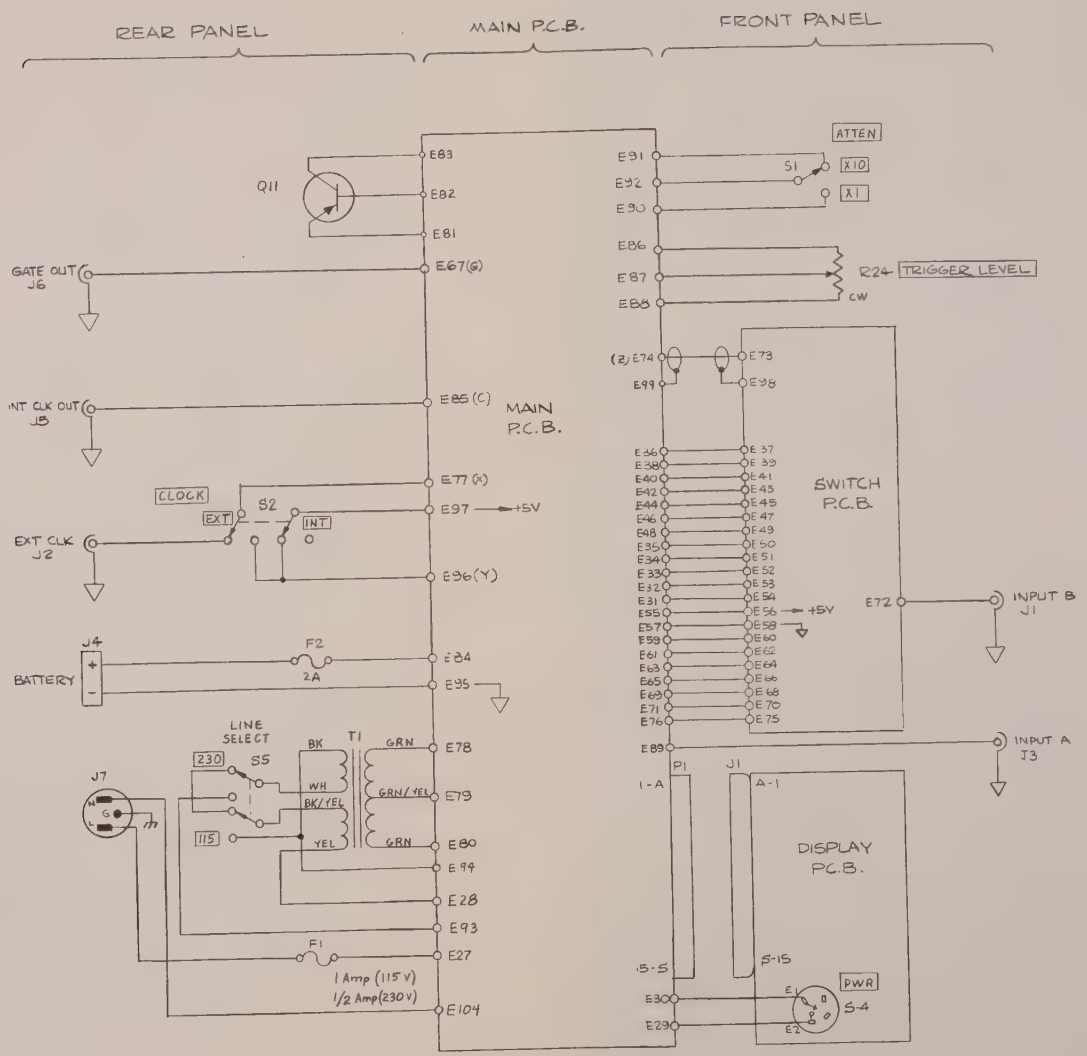


Figure 6-1 TCXO STABILITY

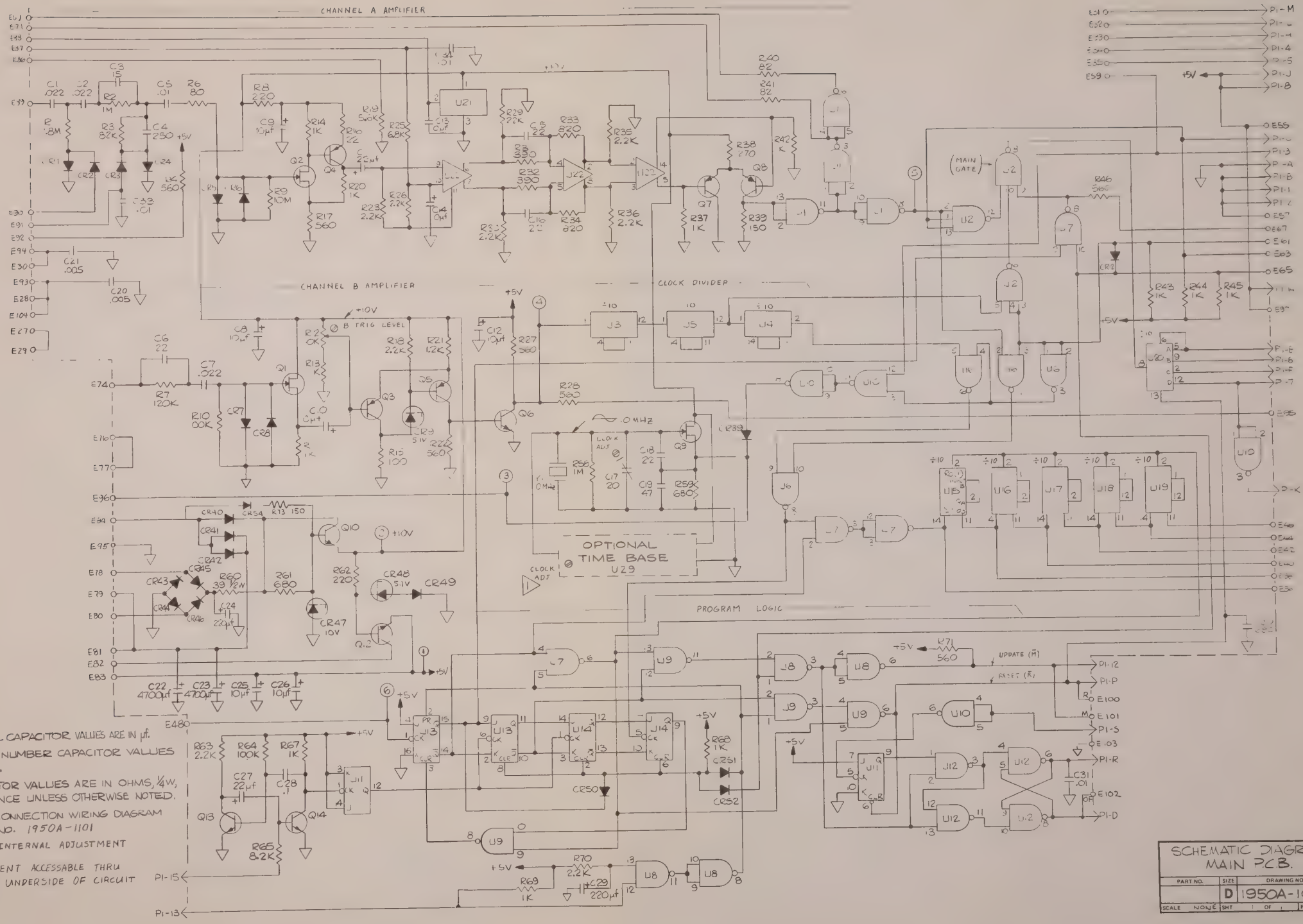
Section 7
Schematic Diagrams

SCHEMATIC DIAGRAMS 7-1

1950A-1101 INTERCONNECT WIRING DIAGRAM. 7-3
1950A-1001 SCHEMATIC DIAGRAM, MAIN PCB 7-5
1950A-1002 SCHEMATIC DIAGRAM, DISPLAY PCB 7-7
1950A-1003 SCHEMATIC DIAGRAM, SWITCH PCB 7-9



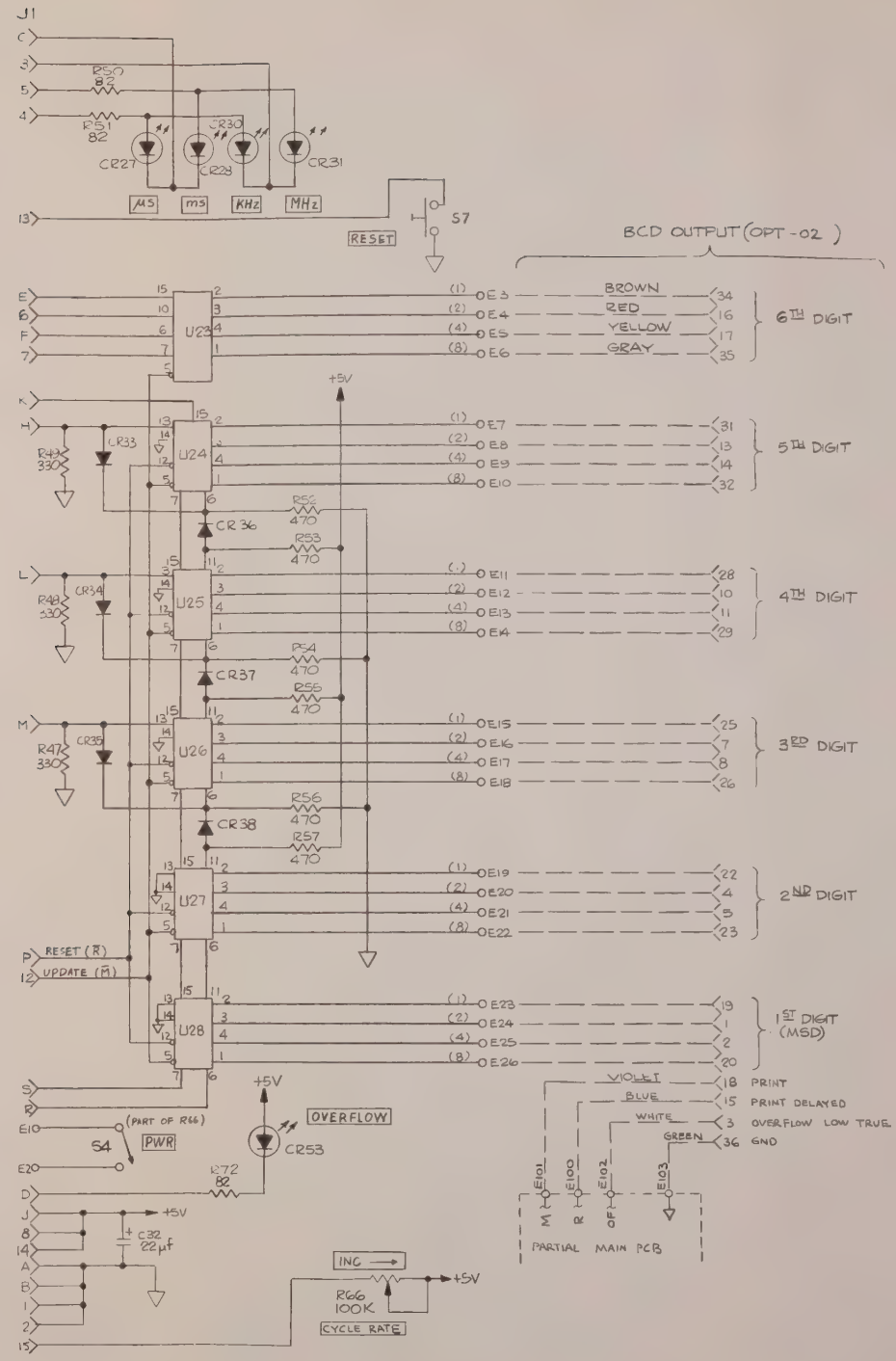
INTERCONNECT WIRING DIAGRAM		
PART NO.	SIZE	DRAWING NO.
	D	1950A-1101
SCALE NONE	SHT 1 OF 1	REV —



NOTES:

1. ALL DECIMAL CAPACITOR VALUES ARE IN μf.
2. ALL WHOLE NUMBER CAPACITOR VALUES ARE IN pf.
3. ALL RESISTOR VALUES ARE IN OHMS, ¼W, 5% TOLERANCE UNLESS OTHERWISE NOTED.
4. FOR INTERCONNECTION WIRING DIAGRAM SEE DWG NO. 1950A-1101
5. ⊘ DENOTES INTERNAL ADJUSTMENT
6. ▷ ADJUSTMENT ACCESSABLE THRU HOLE IN UNDERSIDE OF CIRCUIT BOARD

SCHEMATIC DIAGRAM, MAIN P.C.B.			
PART NO.	SIZE	DRAWING NO.	
	D	1950A-1001	
SCALE NONE	SHT 1 OF 1	REV A	



NOTES:

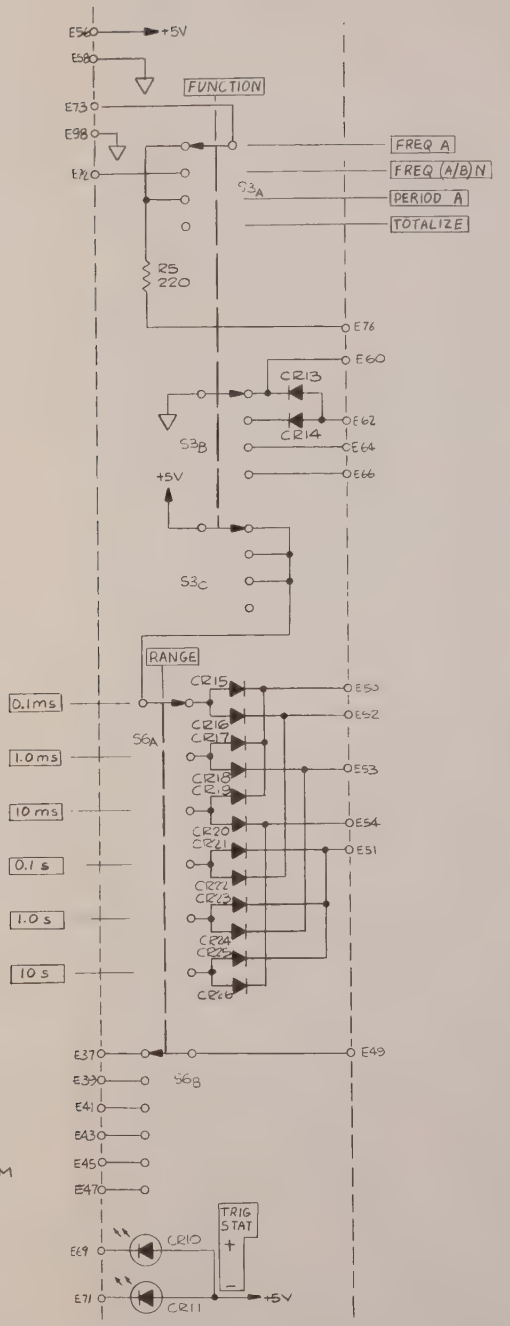
1. ALL DECIMAL CAPACITOR VALUES ARE IN μf.
2. ALL WHOLE NUMBER CAPACITOR VALUES ARE IN pf.
3. ALL RESISTOR VALUES ARE IN OHMS, ¼W, 5% TOLERANCE UNLESS OTHERWISE NOTED.
4. PIN REFERENCE DESIGNATIONS U23 THRU U28

LATCH OUTPUT QB	1	16	SUPPLY VOLTAGE Vcc
LATCH OUTPUT QC	2	15	CLOCK INPUT
LATCH OUTPUT QD	3	14	BLANKING INPUT
LATCH OUTPUT QA	4	13	DECIMAL POINT INPUT
LATCH STROBE INPUT	5	12	CLEAR INPUT
RIPPLE BLANKING INPUT	6	11	RIPPLE BLANKING OUTPUT
MAXIMUM COUNT OUTPUT	7	10	SERIAL COUNT ENABLE INPUT
GROUND	8	9	PARALLEL COUNT ENABLE INPUT

5. FOR INTERCONNECTION WIRING DIAGRAM SEE DWG NO. 1950A-1101

SCHEMATIC DIAGRAM
DISPLAY PCB & -02 OPTION

PART NO.	SIZE	DRAWING NO.
	D	1950A-1002
SCALE NONE	SHT 1 OF 1	REV —



NOTES: UNLESS OTHERWISE NOTED,

1. ALL DECIMAL CAPACITOR VALUES ARE IN μf.
2. ALL WHOLE NUMBER CAPACITOR VALUES ARE IN pf.
3. ALL RESISTOR VALUES ARE IN OHMS, ¼W, 5% TOLERANCE.
4. FOR INTERCONNECTION WIRING DIAGRAM SEE DWG NO. 1950A-1101

SCHEMATIC DIAGRAM, SWITCH PCB

PART NO.	SIZE	DRAWING NO.
	D	1950A-1003
SCALE None	SHT 1 OF 1	REV —

Appendix A

Federal Supply Code for Manufacturers

A-1. CODE TO NAME

A-2. The following five digit code numbers are listed in numerical sequence along with the manufacturer's name and address to which the code has been assigned. The Federal Supply Code has been taken from Cataloging Handbook H 4-2, Code to Name.

00213	Sage Electronics Corp. Rochester, New York
00327	Welwyn International, Inc. Westlake, Ohio
00656	Aerovox Corp. New Bedford, Massachusetts
00686	Film Capacitors Passaic, New Jersey
00779	AMP Inc. Harrisberg, Pennsylvania
01121	Allen-Bradley Co. Milwaukee, Wisconsin
01281	TRW Semiconductors Lawndale, California
01295	Texas Instruments, Inc. Semiconductor Components Div. Dallas, Texas
01686	RCL Electronics Inc. Manchester, New Hampshire
01730	Deleted
01884	Dearborn Electronics Inc. Orlando, Florida
02114	Ferroxcube Corp Saugerties, New York
02606	Replaced by 15801
02660	Amphenol-Borg Elect. Corp. Broadview, Illinois
02799	Arco Capacitors, Inc. Torrence, California
03508	General Electric Co. Semiconductor Products Syracuse, New York
03614	Replaced by 71400
03651	Replaced by 44655
03797	Eldema Corp. Compton, California
03877	Transitron Electronic Corp. Wakefield, Massachusetts
03888	Pyrofilm Resistor Co., Inc. Cedar Knolls, New Jersey
03911	Clairex Corp. New York, New York
03980	Muirhead Instruments, Inc. Mountainside, New Jersey
04009	Arrow Hart and Hegemen Electronic Company Hartford, Connecticut
04062	Replaced by 72136
04202	Replaced by 81312
04217	Essex Wire Corp. Wire & Cable Div. Anaheim, California
04221	Aemco, Div. of Midtex Inc. Mankato, Minnesota
04222	Aerovox Corp. (H-Q) Myrtle Beach, South Carolina
04645	Replaced by 75376
04713	Motorola Semiconductor Products Inc. Phoenix, Arizona
05082	Replaced by 94154
05236	Jonathan Mfg. Co. Fullerton, California
05277	Westinghouse Electric Corp. Semiconductor Dept. Youngwood, Pennsylvania
05278	Replaced by 43543
05397	Union Carbide Corp. Electronics Div. Cleveland, Ohio
05279	Southwest Machine & Plastic Co. Los Angeles, California
05397	Union Carbide Corp. Electronics Div. New York, New York
05571	Sprague Electric Co. Pacific Div. Los Angeles, California
05574	Viking Industries Chatsworth, California
05704	Alac, Inc. Glendale, California
05820	Wakefield Engineering Ind. Wakefield, Massachusetts
06001	General Electric Company Capacitor Department Irmo, South Carolina
06136	Replaced by 63743
06473	Amphenol Space & Missile Sys. Chatsworth, California
06555	Beede Electrical Instrument Co. Penacook, New Hampshire
06739	Electron Corp. Littletown, Colorado
06743	Clevite Corp. Cleveland, Ohio
06751	Semcor Div., Components, Inc. Phoenix, Arizona
06860	Gould National Batteries Inc. City of Industry, California
06980	Varian-Limac San Carlos, California
07115	Replaced by 14674
07138	Westinghouse Electric Corp., Electronic Tube Division Elmira, New York
07256	Silicon Transistor Corp Garden City, New York
07263	Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California
07344	Bircher Co., Inc Rochester, New York
07792	Lerma Engineering Corp. Northampton, Massachusetts
07910	Teledyne Corp. (Continental Device) Hawthorne, California
08228	Industro Transistor Corp. Long Island City, New York
08530	Reliance Mica Corp. Brooklyn, New York
08792	Discontinued
08806	General Electric Co. Miniature Lamp Dept. Cleveland, Ohio
08863	Nylomatic Corp. Norristville, Pennsylvania
08988	Skottie Electronics Inc. Archbald, Pennsylvania
09353	C and K Components Watertown, Massachusetts
09423	Scientific Components, Inc Santa Barbara, California
09922	Burndy Corp. Norwalk, Connecticut
11236	CTS of Berne Berne, Indiana
11237	Chicago Telephone of Calif., Inc. (GTC) Paso Robles, California
11358	Discontinued
11403	Best Products Co Chicago, Illinois

11503 Keystone Mfg.
Div. of Axis Industrial Corp.
Warren, Michigan

11726 Quadrdyne Corp.
Santa Clara, California

12014 Chicago Rivet & Machine Co.
Bellwood, Illinois

12040 National Semiconductor Corp.
Danbury, Connecticut

12060 Diodes, Inc.
Chatsworth, California

12136 Philadelphia Handle Co.
Camden, New Jersey

12223 Presin Co., Inc.
Shelton, Connecticut

12327 Freeway Washer & Stamping Co.
Cleveland, Ohio

12480 Replaced by 75042

12617 Hamlin Inc.
Lake Mills, Wisconsin

12697 Clarostat Mfg. Co.
Dover, New Hampshire

12749 James Electronics
Chicago, Illinois

12856 Micrometals
Sierra Madre, California

12954 Dickson Electronics Corp.
Scottsdale, Arizona

12969 Unitrode Corp.
Watertown, Massachusetts

13103 Thermalloy Co.
Dallas, Texas

13511 Amphenol Corp.
Los Gatos, California

13606 Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839 Replaced by 23732

14099 Semtech Corp.
Newbury Park, California

14193 California Resistor Corp.
Santa Monica, California

14300 American Components, Inc.
Conshohocken, Pennsylvania

14655 Cornell-Dubilier Electronics
Newark, New Jersey

14674 Discontinued, see 16299

14752 Electro Cube Inc.
San Gabriel, California

14869 Replaced by 96853

15636 Elec-Trol Inc.
Northridge, California

15801 Fenwal Electronics Inc.
Framingham, Massachusetts

15818 Teledyne Semiconductor
Div. of Teledyne Inc.
Mountain View, California

15849 USECO Inc.
Mt. Vernon, New York

15908 International Business
Machines (IBM)
Essex Junction, Vermont

15909 Replaced by 17870

16299 Corning Glass
Raleigh, North Carolina

16332 Replaced by 28478

16473 Cambridge Scientific Ind. Inc.
Cambridge, Maryland

16742 Paramount Plastics
Downey, California

16758 Delco Radio
Div. of General Motors
Kokomo, Indiana

17001 ITT Cannon
Santa Ana, California

17069 Circuit Structures Lab.
Upland, California

17856 Siliconix, Inc.
Sunnyvale, California

17870 Daven-Div of Thomas A. Edison
Ind. – McGraw - Edison Co.
Manchester, New Hampshire

18083 Deleted

18178 Vactec Inc.
Maryland Heights, Missouri

18612 Vishay Intertechnology
Inc.
Malvern, Pennsylvania

18736 Voltronics Corp.
Hanover, New Jersey

19429 Discontinued, use 89536

19451 Perine Machinery & Supply Co.
Seattle, Washington

19701 Electra Mfg. Co.
Independence, Kansas

20584 Enochs Mfg. Co.
Indianapolis, Indiana

20891 Self-Organizing Systems,
Inc.
Dallas, Texas

22767 ITT Semiconductors
Div. of ITT
Palo Alto, California

23050 Product Comp. Corp.
Mount Vernon, New York

23732 Tracor
Rockville, Maryland

23880 Stanford Applied Engrng.
Santa Clara, California

23936 Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248 Southco
Div. of South Chester Corp.
Lester, Pennsylvania

24655 General Radio Co.
West Concord, Massachusetts

24759 Lenox-Fugle Electronics
Plainfield, New Jersey

25403 Amperex Electronic Corp.
Semiconductor & Receiving
Tube Division
Slatersville, Rhode Island

27014 National
Semiconductor
Corp.
Santa Clara, California

27264 Molex Products
Downers Grove, Illinois

28425 Bohannon Industries
Fort Worth, Texas

28478 Deltrol Controls,
Corp.
Milwaukee, Wisconsin

28480 Hewlett Packard
Co.
Palo Alto, California

28520 Heyman Mfg. Co.
Kenilworth, New Jersey

29083 Monsanto, Co., Inc.
Santa Clara, California

30323 Illinois Tool
Works, Inc.
Chicago, Illinois

32539 Mura Corp.
Great Neck, New York

32767 Griffith Plastic
Products Co.
Burlingame, California

32879 Advanced Mechanical
Components
Northridge, California

32897 Erie Technological
Products, Incorporated
Frequency Control Div.
Carlisle, Pennsylvania

33173 General Electric
Co., Tube Dept.
Owensboro, Kentucky

34333 Silicon General
Westminister, California

34335 Advanced Micro
Devices,
Sunnyvale, California

37942 Mallory, P. R. & Co., Inc.
Indianapolis, Indiana

42498 National Company
Melrose, Massachusetts

43543 Nytronics Inc.
Transformer Co. Div.
Alpha, New Jersey

44655 Ohmite Mfg. Co.
Skokie, Illinois

49671 Radio Corp. of America
New York, New York

49956 Raytheon Company
Lexington, Maine

53021 Sanamo Electric Co.
Springfield, Illinois

55026 Simpson Electric Company
Chicago, Illinois

56289 Sprague Electric Co.
North Adams, Massachusetts

58474 Superior Electric Co.
Bristol, Connecticut

60399 Torrington Mfg. Co.
Torrington, Connecticut

62460 Deleted

63743 Ward Leonard Electric Co.
Mount Vernon, New York

64834 West Mfg. Co.
San Francisco, California

65092 Weston Instruments Inc.
Newark, New Jersey

66150 Winslow Tele-Tronics Inc.
Asbury Park, New Jersey

70563 Amperite Company
Union City, New Jersey

70903 Belden Mfg. Co.
Chicago, Illinois

71002 Birnbach Radio Co., Inc.
New York, New York

71236 "I T M I N C O"
Willimantic, Connecticut

71400 Bussmann Mfg.
Div. of McGraw - Edison Co.
Saint Louis, Missouri

71450 CTS Corp.
Elkhart, Indiana

71468 ITT Cannon Electric Inc.
Los Angeles, California

71482 Clare, C. P. & Co.
Chicago, Illinois

71590 Centralab
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707 Coto Coil Co., Inc.
Providence, Rhode Island

71744 Chicago Miniature Lamp Works
Chicago, Illinois

71785 Cinch Mfg. Co. & Howard
B. Jones Div.
Chicago, Illinois

72005 Driver, Wilbur B., Co.
Newark, New Jersey

72092 Replaced by 06980

72136 Electro Motive Mfg. Co.
Willimantic, Connecticut

72259 Nytronics Inc.
Berkeley Heights, New Jersey

72354 Deleted

72619 Dialight Corp.
Brooklyn, New York

72653 G. C. Electronics
Rockford, Illinois

72665 Replaced by 90303

72794 Dzus Fastener Co., Inc.
West Islip, New York

72928 Gudeman Co. (Gulton
Industries)
Chicago, Illinois

72982 Erie Tech. Products Inc.
Erie, Pennsylvania

73138 Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293 Hughes Aircraft Co.
Electron Dynamics Div.
Torrence, California

73445 Amperex Electronic Corp.
Hicksville, New York

73559 Carling Electric Inc.
Hartford, Connecticut

73586 Circle F Industries
Trenton, New Jersey

73734 Federal Screw Products, Inc
Chicago, Illinois

73743 Fischer Special Mfg. Co.
Cincinnati, Ohio

73899 JJD Electronics Co.
Brooklyn, New York

73949 Guardian Electric Mfg. Co
Chicago, Illinois

74199 Quam Nichols Co.
Chicago, Illinois

74217 Radio Switch Corp.
Marlboro, New Jersey

74276 Signalite Inc.
Neptune, New Jersey

74306 Piezo Crystal Co.
Carlisle, Pennsylvania

74542 Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970 Johnson, E. F., Co.
Waseca, Minnesota

75042 IRC Inc. (Div. of TRW)
Philadelphia, Pennsylvania

75376 Kurz-Kasch, Inc.
Dayton, Ohio

75382 Kulka Electric Corp.
Mount Vernon, New York

75915 Littlefuse Inc.
Des Plaines, Illinois

76854 Oak Mfg. Co.
Crystal Lake, Illinois

77342 Potter & Brumfield
Div. of Amer. Machine & Foundry
Princeton, Indiana

77969 Rubbercraft Corp. of Calif. LTD.
Torrance, California

78189 Shakeproof
Div. of Illinois Tool Works
Elgin, Illinois

78277 Sigma Instruments, Inc.
South Braintree, Massachusetts

78488 Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553 Tinnerman Products
Cleveland, Ohio

79136 Waldes Kohinoor Inc.
Long Island City, New York

79497 Western Rubber Company
Goshen, Indiana

79963 Zierick Mfg. Corp.
New Rochelle, New York

80031 Mepco
Div. of Sessions Clock Co.
Morristown, New Jersey

80145 API Instruments Co.
Chesterland, Ohio

80183 Sprague Products
North Adams, Massachusetts

80294 Bourns Inc.
Riverside, California

80583 Hammarlund Co., Inc.
Mars Hill, North Carolina

80640 Stevens, Arnold Inc.
Boston, Massachusetts

81073 Grayhill Inc.
La Grange, Illinois

81590 Korry Mfg. Co.
Seattle, Washington

81312 Winchester Electronics
Div. of Litton Industries
Oakville, Connecticut

81439 Therm-O-Disc Inc.
Mansfield, Ohio

81483 International Rectifier Corp.
Los Angeles, California

81741 Chicago Lock Corp.
Chicago, Illinois

82305 Palmer Electronics
South Gate, California 90280

82389 Switchcraft Inc.
Chicago, Illinois

82415 Price Electric Corp.
Frederick, Maryland

82872 Roanwell Corp.
New York, New York

82877 Rotron Mfg. Co., Inc.
Woodstock, New York

82879 ITT Wire & Cable Div.
Pawtucket, Rhode Island

83003 Varo Inc.
Garland, Texas

83298 Bendix Corp.
Electric Power Division
Eatontown, New Jersey

83330 Smith, Herman H., Inc.
Brooklyn, New York

83478 Rubbercraft Corp. of America
New Haven, Connecticut

83594 Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740 Union Carbide Corp.
Consumer Products Div.
New York, New York

84171 Arco Electronics, Inc.
Great Neck, New York

84411 TRW
Ogallala, Nebraska

86577 Precision Metal Products
Stoneham, Massachusetts

86684 Radio Corp. of America
Electronic Components & Devices
Harrison, New Jersey

86689 Deleted

87034 Marco-Oak Inc.
Anaheim, California

88245 Litton Products Inc.
Van Nuys, California

88419 Use 14655

88690 Replaced by 04217

89536 Fluke, John Mfg. Co., Inc.
Seattle, Washington

89730 Replaced by 08806

90201 Mallory Capacitor Co.
Indianapolis, Indiana

90215 Best Stamp & Mfg. Co
Kansas City, Missouri

90211 Square D Co.
Chicago, Illinois

90303 Mallory Battery Co.
Tarrytown, New York

91293 Johanson Mfg. Co.
Boonton, New Jersey

91407 Replaced by 58474

91502 Associated Machine
Santa Clara, California

91506 Augat
Attleboro, Mass.

91637 Dale Electronics Inc.
Columbus, Nebraska

91662 Elco Corp.
Willow Grove, Pennsylvania

91737 Gremar Mfg Co., Inc. (ITT)
Woburn, Massachusetts

91802 Industrial Devices, Inc.
Edgewater, New Jersey

91836 King's Electronics
Tuckahoe, New York

91929 Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934 Miller Electric Co., Inc.
Pawtucket, Rhode Island

93332 Sylvania Electric Products
Semiconductor Products Div
Woburn, Massachusetts

94145 Replaced by 49956

94154 Tung-Sol
Div. of Wagner Electric Corp.
Newark, New Jersey

95146 Alco Electronics Products Inc.
Lawrence, Massachusetts

95263 Leecraft Mfg. Co.
Long Island City, New York

95264 Replaced by 98238

95275 Vitramon Inc
Bridgeport, Connecticut

95303 Radio Corp. of America
Solid State & Receiving Tube Div
Cincinnati, Ohio

95354 Methode Mfg. Corp.
Rolling Meadows, Illinois

95712 Dage Electric Co., Inc
Franklin, Indiana

95987 Weckesser Co., Inc.
Chicago, Illinois

96733 San Fernando Electric Mfg. Co.
San Fernando, California

96853 Rustrak Instrument Co.
Manchester, New Hampshire

96881 Thomson Industries, Inc.
Manhasset, New York

97540 Master Mobile Mounts
Div. of Whitehall Electronics Corp.
Los Angeles, California

97913 Industrial Electronic Hdware Corp.
New York, New York

97945 White, S. S. Co.
Plastics Div.
New York, New York

97966 Replaced by 11358

98094 Replaced by 49956

98159 Rubber-Teck, Inc.
Gardena, California

98278 Microdot Inc.
Pasadena, California

98291 Sealectro Corp.
Conhex Div.
Mamaroneck, New York

98388 Accurate Rubber & Plastics
Culver City, California

98743 Replaced by 12749

98925 Deleted

99120 Plastic Capacitors, Inc.
Chicago, Illinois

99217 Southern Electronics Corp.
Burbank, California

99392 SFM
Oakland, California

99515 Marshall Industries
Capacitor Div
Monrovia, California

99779 Barnes Corp.
Lansdowne, Pennsylvania
Toyo Electronics
(R-Ohm Corp.)
Irvine, California 92664

National Connector
Minneapolis, Minn 55436

Appendix B

List of Abbreviations

alternating current	ac
ampere	A
assembly	assy
binary coded decimal	bcd
bel	B
capacitor	cap
centimeter	cm
ceramic	cer
clockwise	cw
common-mode rejection ratio	cmrr
composition	comp
counterclockwise	ccw
decibel	dB
degree Celsius	°C
degree Fahrenheit	°F
digital voltmeter	dvm
direct current	dc
electrolytic	elect
external	ext
farad	F
field effect transistor	FET
germanium	Ge
giga (10^9)	G
gigahertz	GHz
ground	gnd
guard	gd
henry	H
hertz	Hz
high frequency	hg
hour	h
inch	in
integrated circuit	IC
intermediate frequency	if
internal	intl
kilo (10^3)	k
kilohertz	kHz
kilohm	kΩ
kilovolt	kV
low frequency	lf
maximum	max
mega (10^6)	M
megahertz	MHz
megohm	MΩ
meter	m
micro (10^{-6})	μ
microsecond	μs
milli (10^{-3})	m
milliamperes	mA
millimeter	mm
millisecond	ms
millivolt	mV
minimum	min
nano (10^{-9})	n
nanosecond	ns
negative	neg
ohm	Ω
oscilloscope	scope
parts per million	ppm
peak-to-peak	p-p
pico (10^{-12})	p
picofarad	pF
plus or minus	±
positive	pos
plastic	plstc
printed circuit board	pcb
radio frequency	rf
root mean square	rms
second (time)	s
serial number	SN
silicon	Si
tantalum	Ta
temperature coefficient	TC
tera (10^{12})	T
transformer	xfmr
transistor	xstr
ultra high frequency	uhf
variable	var
very high frequency	vhf
very low frequency	vlf
volt	V
voltage controlled oscillator	vco
watt	W
wirewound	ww

Appendix C

Sales Representatives

ALABAMA

HUNTSVILLE
BCS Associates, Inc.
3322 S. Memorial Parkway
P.O. Box 1273
Tel. (205) 881-6220
Zip 35801

ALASKA

SEATTLE
Showalter-Judd, Inc.
5616 4th Ave. South
Tel. (206) 762-2310
Zip 98108

ARIZONA

PHOENIX
Barnhill Associates
7329 E. Stetson Dr.
Tel. (602) 947-7841
Scottsdale, AZ 85251

CALIFORNIA

LOS ANGELES
Instrument Specialists, Inc.
1109 S. Central Ave.
Glendale, California 91204
Tel. (213) 245-9404

SANTA CLARA
Instrument Specialists, Inc.
2359 De La Cruz Blvd.
Tel. (408) 244-1505
Zip 95050

SAN DIEGO
Instrument Specialists, Inc.
4805 Mercury St., Ste. 1
Tel. (714) 565-2555
Zip 92111

COLORADO

DENVER
Barnhill Associates
1170 S. Sheridan Blvd.
Tel. (303) 934-5505
Zip 80226

CONNECTICUT

HARTFORD
Instrument Representatives, Inc.
P.O. Box 165
Glastonbury, Connecticut 06033
Tel. (203) 633-0777

FLORIDA

ORLANDO
BCS Associates, Inc.
940 N. Fern Creek Ave.
Tel. (305) 896-4881
Zip 32803

HAWAII

HONOLULU
Industrial Electronics, Inc.
646 Queen Street
P.O. Box 135
Tel. (808) 533-6095
Zip 96817

ILLINOIS

CHICAGO
Cozzens & Cudahy, Inc.
1301 N. Rand Rd.
Des Plaines, IL 60016
Tel. (312) 298-3600

INDIANA

INDIANAPOLIS
Cozzens & Cudahy, Inc.
Port O'Call Executive Ctr.
21 Beachway Drive
Tel. (317) 244-2456
Zip 46224

MARYLAND

BALTIMORE
Electronic Marketing Assoc. Inc.
11501 Huff Court
Kensington, Maryland 20795
Tel. (301) 881-5300, 744-7700

MASSACHUSETTS

BOSTON
Instrument Representatives, Inc.
109 Massachusetts Ave.
Lexington, MA 02173
Tel. (617) 861-8620

MICHIGAN

DETROIT
WKM Associates, Inc.
1474 East Outer Dr.
Tel. (313) 892-2500
Zip 48234

MINNESOTA

MINNEAPOLIS
Cozzens & Cudahy, Inc.
10800 Lyndale Ave. S.
Tel. (612) 884-4336
Zip 55420

MISSOURI

ST. LOUIS
Cozzens & Cudahy, Inc.
P.O. Box 10013
Lambert Field - Zip 63145
Tel. (314) 423-1234

NEW JERSEY

NEWARK
SBM Representatives
1519 Stuyvesant Avenue
Union, New Jersey 07083
Tel. (201) 687-8737

NEW MEXICO

ALBUQUERQUE
Barnhill Associates
1410 — D Wyoming N.E.
Tel. (505) 299-7658
Zip 87112

NEW YORK

NEW YORK
SBM Representatives
28 Hobby Street
Pleasantville, N.Y. 10570
Tel. (914) 769-1811

ROCHESTER
SBM Representatives
4515 Culver Rd.
Tel. (716) 226-1400
Zip 14622

NORTH CAROLINA

GREENSBORO
P.O. Box 9619
1310 Beahan Pl.
Tel. (919) 273-1918
Zip 27408

OHIO

CLEVELAND
WKM Associates, Inc.
16141 Puritas Ave.
Tel. (216) 267-0445
Zip 44135

DAYTON
WKM Associates, Inc.
6073 Far Hills Ave.
Tel. (513) 434-7500
Zip 45459

PENNSYLVANIA

PHILADELPHIA
Electronic Marketing Assoc.
210 Goddard Blvd., Ste. 100
King of Prussia, Pennsylvania
Tel. (215) 248-5050
Zip 19406

PITTSBURGH
WKM Associates, Inc.
90 Clairton Blvd.
Tel. (412) 892-2953
Zip 15236

TEXAS

DALLAS
Barnhill Associates
Suite 220
312 N. Central Express Wy.
Richardson, Texas 75080
Tel. (214) 231-2573

HOUSTON
Barnhill Associates
Suite 332
3810 Westheimer
Tel. (713) 621-0040
Zip 77027

WASHINGTON

SEATTLE
Showalter-Judd, Inc.
5616 4th Ave. South
Tel. (206) 762-2310
Zip 98108

CANADA

BRITISH COLUMBIA

VANCOUVER
Allan Crawford Associates, Ltd.
1820 Pandora St.
Tel. (604) 253-7136

ALBERTA

CALGARY
Allan Crawford Associates, Ltd.
640 - 11th Ave. S.W.
Tel. (403) 261-0780

ONTARIO

MALTON
Allan Crawford Associates, Ltd.
6427 Northam Drive
Tel. (416) 678-1500

OTTAWA, 3
Allan Crawford Associates, Ltd.
376 Churchill Ave., Suite 106
Tel. (613) 829-9651

QUEBEC

LONGUEUIL
Allan Crawford Associates, Ltd.
157 (rue) St. Charles Street W.
Tel. (514) 670-1212

INTERNATIONAL REPRESENTATIVES

ARGENTINA
Coasin S.A.
Virrey del Pino 4071
Buenos Aires, Argentina

AUSTRALIA
Elmeasco Instruments
P.O. Box 334
Brookvale, N.S.W. Australia 2100

AUSTRIA
Kontron GMBH & Co., Kg.
Lederergasse 16
1080 Vienna, Austria

BELGIUM
C.N. Rood S.A.
37 Place de Jamblinne de Meux
1040 Brussels, Belgium

BRAZIL
Ambriex S.A.
Rue Ceara, 104 - 2.° e 3.° Andares
ZC - 29
Rio de Janeiro GB, Brazil

Ambriex S.A.
Rua Tupi, 535
01233 Sao Paulo SP, Brazil

CARIBBEAN
West Indies Sales Co.
606 Calle Aboy
San Juan, Puerto Rico 00907

CHILE
Coasin Chile Ltd.
Casilla 14588 - Correo 15
Santiago, Chile

CHINA, Peoples Republic Of
May Lee Industries, Inc.
475 Park Avenue South
New York, N.Y. 10016

COLOMBIA
Marones Ltda.
Apartado Aereo 90687
Bogota 8, Colombia

DENMARK
Tage Olsen A/S
1, Rønnegade
Copenhagen Ø, Denmark

ECUADOR
Proteco Coasin Cia., Ltda.
Apartado 228A
Quito, Ecuador

FINLAND
Oy Findip AB
P.O. Box 25
00521 Helsinki 52, Finland

FRANCE
M.B. Electroniques S.A.
29, Rue Emile Duclaux
92, Suresnes
France

GERMANY
Fey Elektronische Messgerate
8 Muenchen 19
Horemansstrasse 28
West Germany

GREECE
Marios Dalleggio Representations
2 Alopekis Street
Athens 19 Greece

HONG KONG & MACAU
Gilman & Co., Ltd.
P.O. Box 56
Hong Kong

INDIA
Hinditron Services Pvt. Ltd.
69/A Nepean Sea Road
Bombay-6 India

IRAN
Berkeh Company Ltd.
20 Salm Road, Roosevelt Ave.
Tehran, Iran

ISRAEL
R.D.T. Electronics Engineering Ltd.
19 Prof. Shor Street
Tel-Aviv, Israel

ITALY
Sistrel S.P.A.
Via Giorgio da Sebenico 11-13
Rome, Italy

JAPAN
Toyo Trading Co. Ltd.
P.O. Box 5014
Tokyo International
Tokyo 100-31, Japan

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